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ROENTGEN RAYS IN THE TREATMENT OF CARCINOMA OF THE BRONCHUS

WITH AN ANALYSIS OF 69 CASES TREATED IN THE STATE OF WISCONSIN GENERAL HOSPITAL FROM 1933 TO 1943

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INTRODUCTION

IT IS generally conceded that, where feasible, pneumonectomy represents the method of choice in the treatment of early bronchiogenic carcinoma. Most statistics show the immediate operative mortality to range from 30 to 50 per cent,[9, 20, 23] Reinhoff[20] states that with proper selection of cases this can be cut to 10 to 20 per cent, and reports a mortality of but 10 per cent in a series of twenty cases. However, the higher initial risk incurred with radical surgery is warranted in view of the paucity of reports in the literature of five-year survivals of patients who were treated by irradiation only.

The vast majority of patients with bronchiogenic carcinoma are no longer operable when they present themselves for diagnosis. Watson and Urban[23] found that in only 26 per cent of their cases could surgery be considered. Our statistics would probably show an even lower figure since 42 per cent of this series had known metastases when first seen. While in the operable group it is even possible that certain cancers, particularly the epidermoid, are more amenable to irradiation than to surgical treatment, in a large percentage of cases x-ray therapy is all that can be offered.

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Steiner[21] and Bloch and Bogardus[2] believe that irradiation neither significantly alleviated the symptoms or lengthened the survival period in their groups of patients, but most other workers in the field feel that it is definitely beneficial both as a palliative measure and as one that will prolong life. Leddy,[13] in a recent article, gives an excellent summary of results to date, to which the reader is referred.

THERAPY

Methods Used in Other Clinics.—Bronchiogenic carcinoma, in general, is highly radioresistant. Surviving cells are found after tumor doses of 5000 r, and the cancerocidal dose is probably higher.[21] The mediastinal structures and lungs can tolerate dosage closely approaching the skin tolerance limit.[5, 6, 21]

While up to the present time efforts have been directed chiefly toward palliation, with the advent of high and supervoltage machines, there is an increasing trend toward attempting a five-year arrest in cases where there are no obvious metastases. Such therapy to be effective on a radioresistant tumor necessitates the use of adequately filtered high voltage beams, properly centered, and small ports to avoid irradiating normal structures as much as is possible. Craver,[4, 5] Holmes,[9] and Watson and Urban[23] advocate an attempt to control the cancer in the first cycle of therapy, finding that subsequent cycles are less effective in arresting the process, and in some cases appear to be harmful. Craver uses 200 to 700 kv. radiation, a minimum of .5 mm. Cu filtration, 75 to 100 cm. F.S.D., two portals of entry (anterior and posterior), and administers 200 to 300 r to one portal daily, up to full skin tolerance, in an effort to deliver a tumor dose of 3,000 to 4,000 r. An analysis of his patients shows that those receiving tumor doses of under 1,000 r in the first cycle had an average survival of 4.3 months, while those receiving from 2,000 to 3,000 r had an average survival of 8.2 months after therapy, and 18.9 months after the known onset. Those receiving from 3,000 to 4,000 r had an average survival of only 5.4 months, but there were only four cases in this series. He found little significant difference in survival figures, when correlated with histology, but better palliation in the epidermoid group. His two-year survival rate was 7 per cent, and the five-year survival rate 3.8 per cent. Holmes uses very much the same method, employing 200 to 1,200 kv. He reports no five-year arrests, but excellent palliation in many cases, best in the epidermoid group. Watson and Urban[23] recently published twenty-five completed cases treated with one million volt therapy, and stated that thus far results had not justified the initial enthusiasm. They also used an anterior and a posterior 10 by 15 cm.^{2} portal, 70 cm. F.S.D., 200 r daily until skin tolerance was reached in an effort to give a tumor dose of over 3,000 r. The average survival of the twenty-three deceased patients was 7.3 months. Patients received an average tumor dose of

4,400 r. It was found that 3,000 to 4,000 r produced the maximum palliation, and 5,000 to 7,000 r the longest survival period. After reviewing the series of cases, Leddy[13] and Leddy and Moersch[14] concluded that intensity or type of therapy had very little to do with the final results. Leddy's present method consists of three courses of therapy, one to two months apart. Each course consists of 4 x 560 r, 200 kv., 50 cm. F.S.D., filtration of ¾ mm. Cu and 1 mm. Al. Four fields are used, and one is treated daily. He reports five five-year arrests, all adenocarcinomas graded 1 to 4, and concludes that adenocarcinoma responds more favorably than epidermoid carcinoma. Other writers,[1, 3, 9, 11] however, are of the opinion that it is difficult in a bronchoscopic biopsy to differentiate a carcinoma from an adenomatous growth and that many of the long-term arrests reported with such tumors are in reality in patients with benign papillomas.

Our Methods.—With increased experience with these cases, and especially with the availability of more penetrating radiation for their treatment, there have been changes in our method of therapy during the past ten years. Our experience has been in complete agreement with the generally accepted theory that heavy irradiation to badly infected tissue is dangerous and unwarranted. Since an adequate depth dose can be obtained with supervoltage through fairly small anterior and posterior portals, lateral and obliques are not used, thus avoiding the exposure of large amounts of noninvolved lung tissue. The tumor is accurately localized roentgenoscopically or roentgenographically, and the portals outlined on the skin with some indelible marking. An attempt is made to exclude the areas of surrounding infection and atelectasis. However, the hilar nodes are usually included unless the tumor is of the peripheral type. Planograms and bronchoscopic findings are of value in determining the extent of the neoplasm. Most of our cases fall into one of three groups.

An Attempt to Deliver a Carcinocidal Dose Seems Justified: Two series of therapy are given, three months apart. The first consists of 12 x 200 r or 20 x 150 r (measured in air) to each portal, 400 kv., 5 Ma., 50 cm. F.S.D., HVL in Cu 2.4 mm.; both are treated daily. Portals vary from 10 by 10 to 15 by 15 cm.[2] Patients are observed carefully and if necessary the series is shortened. In the average chest of 21 cm. diameter, 3,000 r in air through each of two 10 by 10 cm.[2] portals give an approximate tumor dose of 2,500 r. A roentgenogram of the chest is taken six weeks later to note any change. The second series consists of 8 to 10 x 200 r or 10 to 12 x 150 r. Further irradiation is then given in small amounts not less than three months apart for the control of symptoms, metastases, or increased tumor size. As indicated in the case histories appended, such irradiation has at times been of great value in checking renewed growth, after the mass has remained stationary for some time.

Advanced Cases, Where General Debility, Extent of Lesion, or Marked Obstruction With Concomitant Infection Contraindicate Intensive Therapy: Patients with advanced cases are given a series of 4 to 8 x 200 r to each portal in an attempt to alleviate symptoms, decrease pleural fluid formation, or establish drainage. Should drainage be established during therapy, they may be given more intensive irradiation. Aspiration precedes therapy in cases with pleural effusion. Six weeks later the case is re-evaluated, and if there has been satisfactory response, or clearing of atelectasis or infection, a single intensive series may be given in another six weeks. Otherwise, short cycles are repeated at intervals of not less than three months as indicated for symptomatic control; they usually become increasingly ineffective.

Widespread Metastases; Pulmonary and Skeletal: The metastatic lesions are treated primarily for control of pain. We have found that, if a series of 6 to 8 x 200 r in air (200 to 400 kv., HVL_{Cu} 1.05-2.4 mm., F.S.D. 50 cm.) through two opposing portals does not give relief, greater dosage is rarely of value. Relief is usually evident within the first four to five days. The primary lesion is irradiated for symptomatic relief if indicated and feasible.

OUR MATERIAL

Sixty-nine patients with bronchiogenic carcinoma have been treated between the years 1933 to 1943. Table I shows the sex and age distribu-

TABLE I

AGE AND SEX INCIDENCE

AGES	NUMBER	MALE	FEMALE
20 to 29	2	2	
30 to 39	1	1	
40 to 49	17	12	5
50 to 59	30	27	3
60 to 69	17	16	1
70 to 80	2	2	
Total	69	60	9

tion. The greatest incidence is in the sixth decade, the ratio of males to females 6:1. A further analysis of these cases is given in Table II.

TABLE II

ANALYSIS OF MATERIAL

CASES	NUMBER	PERCENTAGE
Total cases	69	100
Adequate records	55	80
Metastases present on admission	29	42
Verified diagnosis	42	61
Histologic diagnosis	29	42
Bronchoscopic examination without biopsy	13	20
X-ray and clinical diagnosis	27*	39
Current cases	13*	20

*Two of these cases are not included in survival statistics because of longevity.

Our patients come from all parts of the state, for diagnosis and treatment. After a course of therapy they return to their homes and to the care of their family physician, and come back for periodic examinations or further treatment at our discretion. As a consequence, in the later stages of the disease they are rarely able to undertake the journey to the hospital, so that records are frequently completed by letters from the family physician or relatives. The number of post-mortem examinations is therefore small, and a certain percentage have incomplete records. Fourteen of the sixty-nine patients treated were not seen after the first visit, and we have no further information. Six of these fourteen had widespread metastases, five were far advanced, and therapy was minimal. These eleven presumably died soon after their discharge. The other three refused to complete their outlined series. In fifty-five, or 80 per cent the records are complete. Twenty-nine, or 42 per cent, had metastatic lesions when the diagnosis was first made. Our diagnosis was verified in forty-two, or 61 per cent, by surgical exploration, bronchoscopy, biopsy of a lymph node, or post-mortem examination. In the remaining twenty-seven, or 39 per cent, bronchoscopic findings either were negative or examination was not advisable or possible, and the diagnosis rested upon roentgenologic findings and the subsequent clinical course with development of metastases. In this group, two are omitted from survival statistics because of longevity. One is still alive, fifty-six months after therapy; in this case bronchoscopic examination could not be obtained because of ankylosis of the jaws. The other died of pulmonary hemorrhage seventy months after therapy. Bronchoscopic examination was negative. Histologic proof was obtained in twenty-nine or 42 per cent. In thirteen, or 20 per cent, of the verified cases either a biopsy was not taken when the lesion was visualized bronchoscopically, or the tissue obtained was unsatisfactory for diagnosis. Thirteen cases are current. The histopathology is given in Table III. In six cases, or

TABLE III

HISTOPATHOLOGY

CELL TYPE	NUMBER	PERCENTAGE
Squamous cell grade 1	0	0
Squamous cell grade 2	7	24
Squamous cell grade 3 (transitional)	9	31
Squamous cell grade 4	0	0
Total	16	55
Anaplastic	1	3
Adenocarcinoma	6	21
"Bronchiogenic carcinoma"	6	21
Total	29	100

21 per cent, the specimen was inadequate for any classification other than bronchiogenic carcinoma. Sixteen, or 55 per cent, were epidermoid carcinomas and of these over half were of a high degree of malignancy.

We had but one anaplastic neoplasm. The patient came in with a diagnosis of cerebellar tumor, and the bronchiogenic carcinoma was found in a routine search for a possible primary lesion. Six weeks after therapy (and shortly before death) a roentgenogram of the chest showed almost complete regression of the original mass, illustrating the radiosensitivity that such lesions may display. However, on post-mortem examination, widespread cerebral and visceral metastases were found, showing the concomitant extremely poor prognosis. The approximate duration of symptoms before diagnosis is tabulated in Table IV. The

TABLE IV

AVERAGE DURATION OF SYMPTOMS BEFORE DIAGNOSIS

TIME (MO. INCLUSIVE)	NUMBER	PERCENTAGE
0 to 6	26	37.7
7 to 12	15	21.7
13 to 18	8	11.6
19 to 24	4	5.8
25	2	2.9
Entering complaints referable to metastases only	10	14.5
Incidental finding	1	1.5
No record	3	4.3
Total	69	100

two patients with symptoms extending over twenty-five months are current. They were far advanced when first seen, and apparently clinically in a terminal state two months after the diagnosis was established. One carcinoma was an incidental finding in a routine roentgenogram of the chest. The admitting complaint of the patient was referable to marked osteoarthrosis of the hips. Table V illustrates clearly the usual poor

TABLE V

SURVIVAL AFTER FIRST COURSE OF THERAPY OF 41 COMPLETED CASES WITH ADEQUATE HISTORY

TIME (MO. INCLUSIVE)	NUMBER	PER CENT	METASTASES ON ADMISSION	PER CENT
0 to 3	16	39	11	27
4 to 6	8	19.5	3	7.3
7 to 12	11	27	2	4.7
13 to 18	1	2.4	1	2.4
19 to 24	3	7.3		
25 to 36	1	2.4		
78	1	2.4		
Total	41	100	17	41.4

prognosis. We can probably add eleven of the cases lost to follow-up to the 38 per cent that survived three months or less. However, since 75 per cent of these patients had widespread metastases when first seen, roentgen therapy was purely palliative and minimal. The patient surviving seventy-eight months has been mentioned in other articles,[17, 18] and the history is summarized in Case 1. This is the only five-year

arrest in the series. The histologic diagnosis was "slow-growing bronchiogenic carcinoma" but the subsequent course and development of metastatic lesions are evidence of the malignant character of the neoplasm. Six, or 14 per cent survived over twelve months with an average survival period of 8.6 months in the forty-one cases. There is no definite correlation between the amount of therapy received and the survival period, although in general those receiving more therapy survived longer. This may be due partially to the fact that only those patients in fairly good physical condition received the higher dosage. Twenty of these patients, or about one-half, received a minimum of 4,000 r in air during the first cycle, giving them a minimal tumor dose of about 1,600 r. The average survival period here is 8.1 months. This is within the range obtained by Holmes, Craver, Watson and Urban, although the tumor dose is not as high. When x-ray therapy was used as a means of palliation, the results were more encouraging. Discounting those cases in which only the metastases were treated, 63 per cent of the entire group experienced moderate to marked relief from cough, dyspnea, and pain. Weight gain, and a sense of well being, even though short lived, was common. The current cases are listed in Table VI. Two patients

TABLE VI

SURVIVAL PERIOD OF CURRENT CASES

TIME IN MO. (INCLUSIVE) AFTER FIRST COURSE OF THERAPY	NUMBER	PER CENT	TOTAL SURVIVAL SINCE ONSET OF SYMPTOMS IN MONTHS	METASTASES WHEN FIRST SEEN
0 to 6	9	75		2
7 to 12	1	8.3	13	
13 to 24	1	8.3	19	
43	1	8.3	51	
Total	12	100		

were alive and well sixteen and forty-three months, respectively, after diagnosis, and nineteen and fifty-one months after the apparent onset of symptoms. Both appeared to be in the far advanced group when first seen. The total survival period from known onset to death in our completed cases is given in Table VII; only five, or 12 per cent, lived over two years.

TABLE VII

TOTAL SURVIVAL PERIOD FROM KNOWN ONSET OF SYMPTOMS IN COMPLETED CASES

MO. INCLUSIVE	NUMBER	PER CENT
0 to 6	7	17.1
7 to 12	8	19.5
12 to 24	21	51.2
24 to 36	3	7.3
36 to 48	1	2.4
96	1	2.4
Total	41	100

No correlation could be made between survival, tumor dose, and cell type. This has been the experience of most observers. Quimby[19] noted the same lack of correlation in a series of breast carcinomas. In general, squamous cell carcinomas, group 3, have shown the best response, as illustrated by Cases 2 and 3. Table VIII gives the average total

TABLE VIII

CORRELATION OF CELL TYPE WITH SURVIVAL (CURRENT CASES NOT INCLUDED)

HISTOLOGY	AVERAGE DURATION BEFORE DIAGNOSIS (MO.)	AVERAGE SURVIVAL AFTER THERAPY (MO.)	AVERAGE TOTAL SURVIVAL (MO.)	NUMBER
Squamous cell grade 2	15.5	6.2	21.7	7
Squamous cell grade 3	7.8	13.7	21.5	9
Anaplastic	6	2	8	1
Adenocarcinoma	7.4	7.5	14.9	6
Total				23

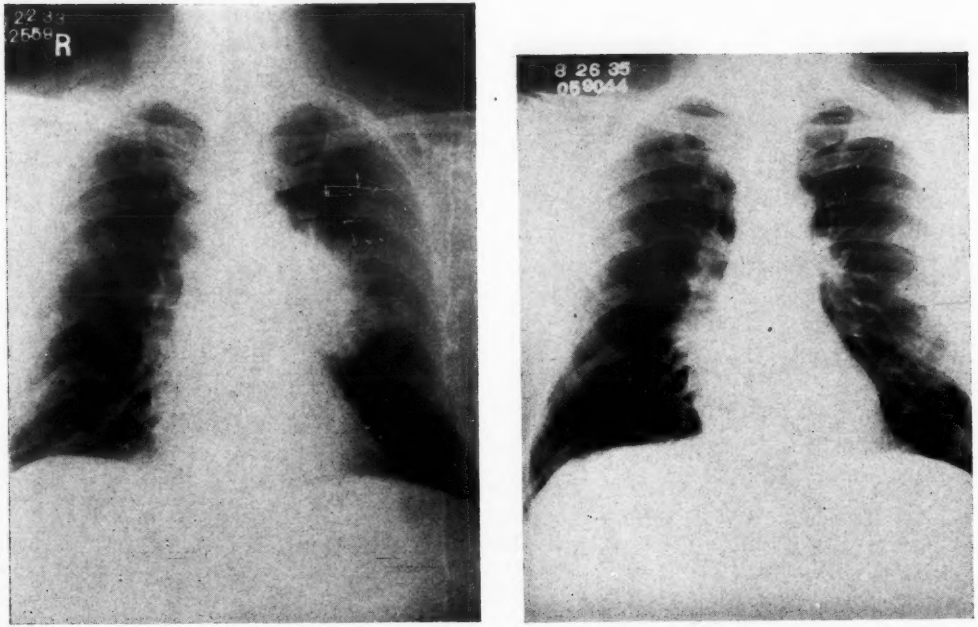
survival period in each histologic group. The current cases are not included. In the entire adenocarcinoma group, the primary lesion was radioresistant; only two carcinomas showed slight regression in subsequent roentgenograms. All developed early and widespread metastases. Group 2 and Group 3 squamous cell carcinomas have the same average survival period, but Group 3 patients presented themselves earlier for diagnosis and lived on an average twice as long after institution of therapy.

CASE HISTORIES

CASE 1 (X-ray No. 2969[17, 18]).—A white man, aged 62 years, was admitted to the State of Wisconsin General Hospital, March 26, 1933, with the chief complaint of cough during the preceding five years. This had increased in severity during the previous eighteen months, with occasional production of blood-tinged sputum. He also had had chest pain and dyspnea for two months, and had lost thirteen pounds in the past two weeks. On physical examination there was a definite area of dullness on the left side of the upper chest, with decreased breath sounds and fine crackling râles. Laboratory findings were essentially normal. Roentgenograms of the chest revealed an irregular triangular area of density with feathery margins extending from the left hilum into the mid-lung field (Fig. 1*A*). Bronchoscopy was done March 28, 1933, and a constricting, obstructive mass was found in the upper left main bronchus. The histologic diagnosis was "slow-growing bronchiogenic carcinoma." Deep roentgen therapy was started April 1, 1933. From April 1 to May 29, he was given a total of 2,250 r per portal, measured in air, over an anterior and posterior 20 by 20 cm.^{2} field, with the central ray focused over the center of the growth. Factors were 180 kv., 6 Ma., F.S.D. 50 cm., .5 mm. Cu + 1.0 mm. Al filters, 150 r per area daily. After six treatments the patient showed definite subjective improvement, with relief from cough and pain. Roentgenograms of the

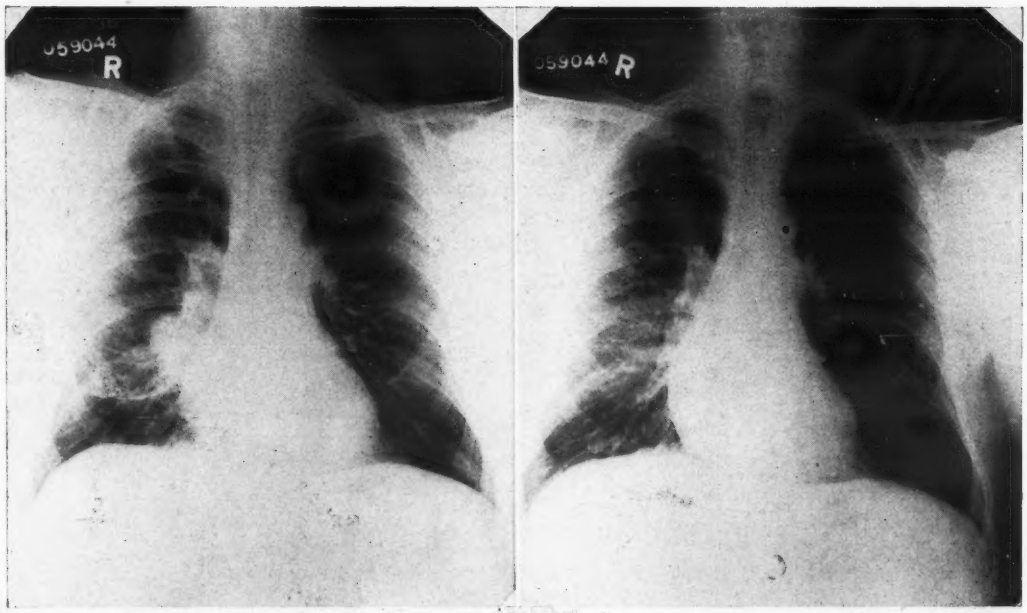
chest, June 26, 1933, showed marked decrease in the size of the neoplasm, and Sept. 6, 1933, still further reduction in size. The patient had gained weight and was working. Nov. 7, 1933, the mass had increased in size again, and a series of 600 r through each of the previous portals with the same factors, 100 r daily to each area, was given. Serial roentgenograms revealed no change until Oct. 22, 1934, when a nodularity of the right hilar shadow was noted. In the early part of 1935, the patient developed evidence of coronary disease. May 14, 1935, a lemon-sized metastatic nodule had appeared in the right supraclavicular area, to which therapy was given totaling 2,000 r, measured in air, 200 r daily, 10 by 10 portal, the same factors as described previously. Two months later this node had disappeared; the chest remained negative (Fig. 1*B*). March 23, 1936, the right hilar process showed definite extension (Fig. 2*A*). From March 23, to May 23, 1936, the patient received a total of 2,400 r per portal, measured in air, through an anterior and posterior portal, 100 to 200 r daily per area. Definite regression of the right hilar tumor was noted in the roentgenograms of the chest, June 29, 1936. When last seen by us, Sept. 14, 1936 (Fig. 2*B*), the patient was in excellent condition. He died Oct. 6, 1939, at home. There was no post-mortem examination. The clinical diagnosis was (1) generalized carcinomatosis, primary unknown; (2) pulmonary hemorrhage. Survival after institution of therapy was six and one-half years.

Case 2 (X-ray No. 9036).—A woman, aged 66 years, was admitted to the State of Wisconsin General Hospital, Dec. 16, 1939, with the chief complaint of "tired weak feeling" in the chest. Other complaints were increasing hoarseness during the preceding eight months, and four attacks of "pleurisy" during the previous six months; no cough. She had moderate dyspnea on exertion for the preceding three years, and had lost forty pounds during that time. On physical examination, the face, lips, and nail beds showed definite cyanosis. Cervical nodes were palpable. The veins were dilated over the left upper side of the chest and there was a definite area of dullness without râles. The blood pressure was 110/80; the blood count as follows: Hb. 11.1 Gm.; red blood count, 4,020,000; white blood count, 13,100 with 55 per cent neutrophiles, 41 per cent lymphocytes, 2 per cent monocytes, and 2 per cent eosinophiles. No abnormal cells were noted. Other laboratory findings were within normal limits. Laryngoscopic examination revealed a chronic laryngitis. A roentgenogram of the chest showed a mediastinal mass extending to both sides of the midline and obscuring the heart borders. The left diaphragm was elevated. The diagnosis was mediastinal tumor consistant with lymphoblastoma (Fig. 3*A*). A biopsy of the cervical lymph node was interpreted as lymphatic leukemia or lymphosarcoma. This was subsequently changed to "chronic lymphadenitis." Roentgen therapy was started Dec. 28, 1939, and she re-



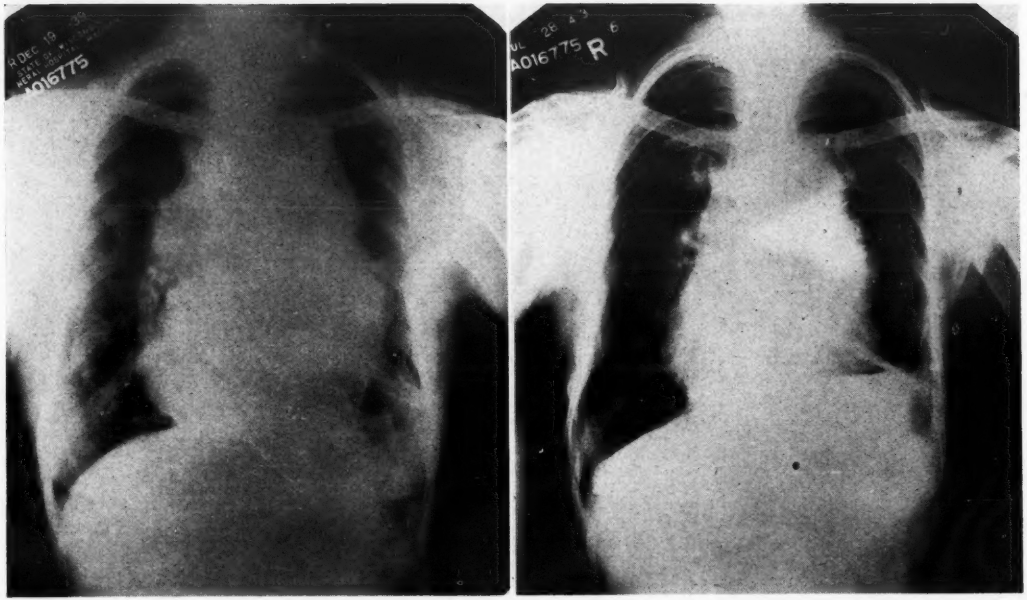
A. *B.*

Fig. 1 (Case 1).—*A*, Roentgenogram of the chest, March 22, 1933, showing mass in the left hilum region. Biopsy showed slow-growing epithelioma. *B*, Roentgenogram of the chest, Aug. 26, 1935, showing regression of the mass. (From Pohle, Ernst A.: Radiation Therapy in Medical Practice. II. Carcinoma of the Lung, Wisconsin M. J. 33: 29, 1934.)



A. *B.*

Fig. 2 (Case 1).—*A*, Roentgenogram of the chest, March 23, 1936, showing extension of the neoplasm in the right hilar region. *B*, roentgenogram of the chest, Sept. 14, 1936, showing regression of the tumor. Two and one-half years after beginning x-ray therapy, total survival period six and one-half years.



A. *B.*

Fig. 3 (Case 2).—*A*, Roentgenogram of the chest, Dec. 19, 1939. Tentative diagnosis was lymphoblastoma; final diagnosis, bronchiogenic carcinoma. *B*, Roentgenogram of the chest, July 28, 1943, showing marked regression of the tumor three and one-half years after beginning x-ray therapy.

ceived 200 r daily to an anterior and posterior 15 by 15 cm.^{2} mediastinal portal, 175 kv., 15 Ma., 50 cm. F.S.D., HVL in Cu 1.05 mm., total 600 r per area. Two similar series of 800 r each were given starting Feb. 9, 1940, and May 9, 1940. After the last treatment, the patient felt much improved, the cyanosis had disappeared, and she had gained five

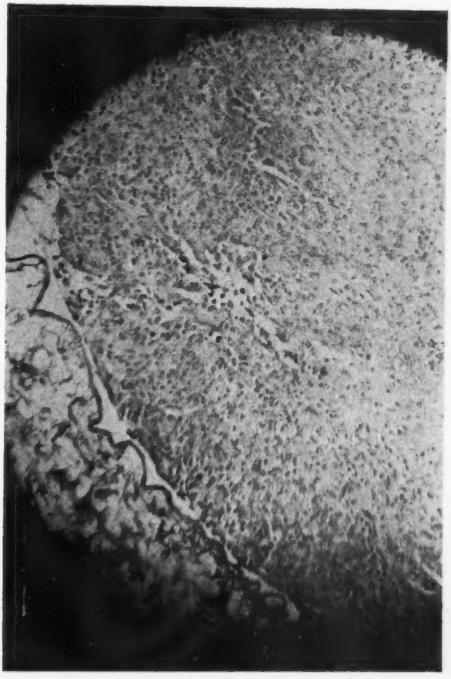
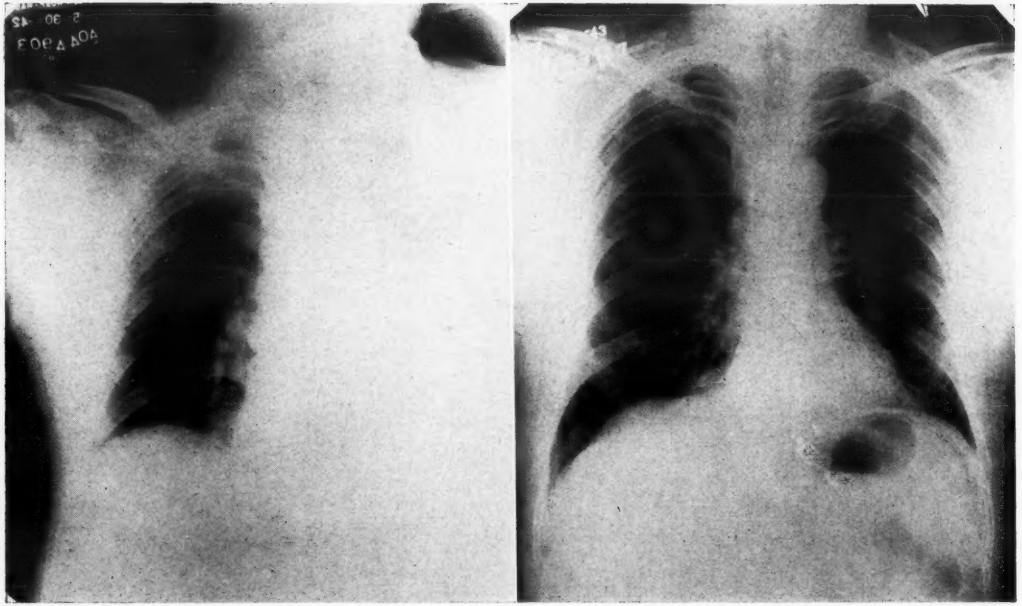


Fig. 4 (Case 2).—Photomicrogram of biopsy taken from an axillary node: Squamous cell carcinoma, grade 3, probably originating from a bronchus.

pounds. The mediastinal mass had decreased only moderately in size, and the blood count was essentially unchanged. Sternal puncture, in July, 1941, revealed no evidence of leukemia. Therefore, a small palpable axillary node was excised for biopsy. This was diagnosed squamous cell carcinoma grade 3, probably arising from the bronchus and the diagnosis of mediastinal mass was changed to bronchiogenic carcinoma (Fig. 4). The tumor had increased in size, and deep therapy totaling 1,600 r, measured in air, was given to each of the mediastinal portals. The factors were changed to 400 kv., 5 Ma., 50 cm. F.S.D., HVL in Cu 2.4 mm., 200 r daily to each area. A roentgenogram of the chest on Oct. 20, 1941 showed a moderate decrease in the size of the lesion. The patient felt well until Feb. 11, 1943, when she complained of pain in the left side of the chest. Films showed slight extension



A. *B.*

Fig. 5 (Case 3).—*A*, Roentgenogram of the chest, May 30, 1942, showing considerable density in the left side of the chest. Bronchoscopic biopsy showed bronchiogenic carcinoma, squamous cell grade 3. *B*, Roentgenogram of the chest, Oct. 18, 1943. Both lung fields are clear except for a few fibrous strands in the left base, sixteen months after beginning of therapy.

of the primary focus, and a metastatic nodule in the left base. Therapy was directed to the new lesion, factors as described, 10 by 10 cm.^{2} anterior and posterior portals, 200 r daily, totaling 1,600 r per area. A roentgenogram, April 23, 1943, showed disappearance of the metastatic focus; the primary tumor was stationary. When last seen July 28, 1943, she felt exceptionally well, the chest findings remained the same (Fig. 3*B*), and she had been doing all of her housework—three and one-half years after therapy had been instituted.

CASE 3 (X-ray No. 11363).—A man, aged 67 years, was admitted to the State of Wisconsin General Hospital, May, 1942, with complaints of cough, pain in the left side of the chest, weakness, and loss of weight during the previous three months. On physical examination the patient was cyanotic, dyspneic, and appeared exhausted. His temperature was 102° F. There were dullness, decreased breath sounds, and vocal fremitus over the left lower side of the chest. The blood count was as follows: Hb. 11.9; red blood cells, 3,560,000; white blood cells, 8,000 with 82 per cent neutrophiles. Other laboratory findings were essentially normal. A roentgenogram of the chest revealed a considerable density in the left lower lung field consistent with atelectasis (Fig. 5*A*). On bronchoscopic examination, a tumor was found obstructing the opening of the left lower main bronchus. The biopsy report was bronchiogenic carcinoma, squamous cell grade 3. X-ray deep therapy was started June 5, 1942, using two portals of entry, anterior and posterior, 15 by 15 cm.,^{2} with the central ray focused over the center of the growth, 200 r daily to each area (measured in air). The factors used were 175 kv., F.S.D. 50 cm., HVL in Cu 1.05 mm. After he had received 800 r to each area, therapy was discontinued because of nausea and poor general condition. He returned, July 2, 1942, somewhat stronger, but with no alleviation of cough or pain. A roentgenogram of the chest showed increased aeration of the left lower lobe. From July 7, to July 16, 1942 he received a total of 1,200 r through each of the previously described portals, factors being changed to 400 kv., 5 Ma., 50 cm. F.S.D., HVL in Cu 2.4 mm., 200 r daily to each area. When seen three months after this, he had gained weight, had no dyspnea, and had only an occasional cough. The pain had disappeared. A roentgenogram of the chest showed marked improvement, with only a minimal amount of stringy density remaining in the extreme base of the left lung field. He has continued to feel well. When last seen, Oct. 8, 1943, he had gained twenty pounds since the first admission. On repeated bronchoscopic examination no tumor could be found. We realize that this does not necessarily mean that the tumor disappeared. A roentgenogram of the chest showed the lung fields to be clear except for a few fibrous strands in the left base (Fig. 5*B*), sixteen months after the beginning of therapy.

COMMENT

An analysis of the review of our patients with carcinoma of the bronchus brings out the fact that the majority seek medical advice in a fairly advanced stage of the disease. Therefore, the question as to the curability of carcinoma of the bronchus by irradiation cannot be answered fairly from this survey. It seems possible though, in rare instances, that even in the presence of metastases, a five-year survival may be achieved. There is no question regarding the palliative value of cautiously applied x-ray therapy and we strongly recommend giving it a trial as long as the general condition of the patient so permits.

SUMMARY

1. During 1933 to 1943, sixty-nine cases of carcinoma of the bronchus were observed in the department of radiology of the State of Wisconsin General Hospital.

2. Data regarding the age and sex incidence, general analysis of material, histopathology, average duration of symptoms before diagnosis, survival after first course of therapy, survival period of current cases, total survival period from known onset of symptoms in completed cases, and correlation of cell type with survival are tabulated.

3. The methods of treatment practiced in other clinics as well as in our own are described.

4. The greatest value of radiation therapy in patients with carcinoma of the bronchus lies in its palliative effect; only occasionally can a five-year survival be achieved.

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THE DIAGNOSIS AND TREATMENT OF BRONCHIOGENIC CYSTS OF THE MEDIASTINUM AND LUNG

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THERE has been considerable interest recently in so-called bronchiogenic cysts of the chest, and several case reports have been published.[1, 5, 7, 8, 10] At the Massachusetts General Hospital, from 1934 to 1943, twenty-one patients with probable bronchiogenic cyst of lung or mediastinum have been operated on. The cases are here presented with a discussion of certain interesting roentgenologic and surgical aspects.

CLINICAL DIAGNOSIS

The majority of the patients had as their presenting symptom pain, usually in the chest, occasionally in the epigastrium. This pain was due probably to pressure on surrounding structures by the cyst. Substernal pain in one patient was due to concomitant diaphragmatic hernia. A few patients complained of cough, due to pressure on adjoining bronchi. Expectoration of foul sputum indicated infection in the cyst, with bronchial communication. Two patients had had hemoptysis in small degree. Two complained of dysphagia and vomiting, due to the proximity of the cyst to the esophagus. The duration of symptoms varied from one month to twenty-five years. A few of the cysts were discovered incidentally during roentgenologic examinations done routinely or because of unrelated complaints. Such cases, with the increased trend toward group surveys, will become more common.

Bronchoscopy offers little diagnostically except to rule out intrinsic bronchial lesions. Preoperative bronchoscopic examination was carried out in three patients of the series. In one of these, characteristic foul sputum was obtained from the right main bronchus, confirming the history. In another, forward displacement of the trachea was the only finding, confirming the roentgenogram. The third showed nothing abnormal.

ROENTGEN DIAGNOSIS

The diagnosis of bronchiogenic cyst depends largely on roentgen examination. One of its most important phases is fluoroscopy. By means of fluoroscopy it is possible to determine the presence of a lesion, its dynamics, and the necessary films to best demonstrate it. Many or few views may be taken, but it is essential that routine posteroanterior,

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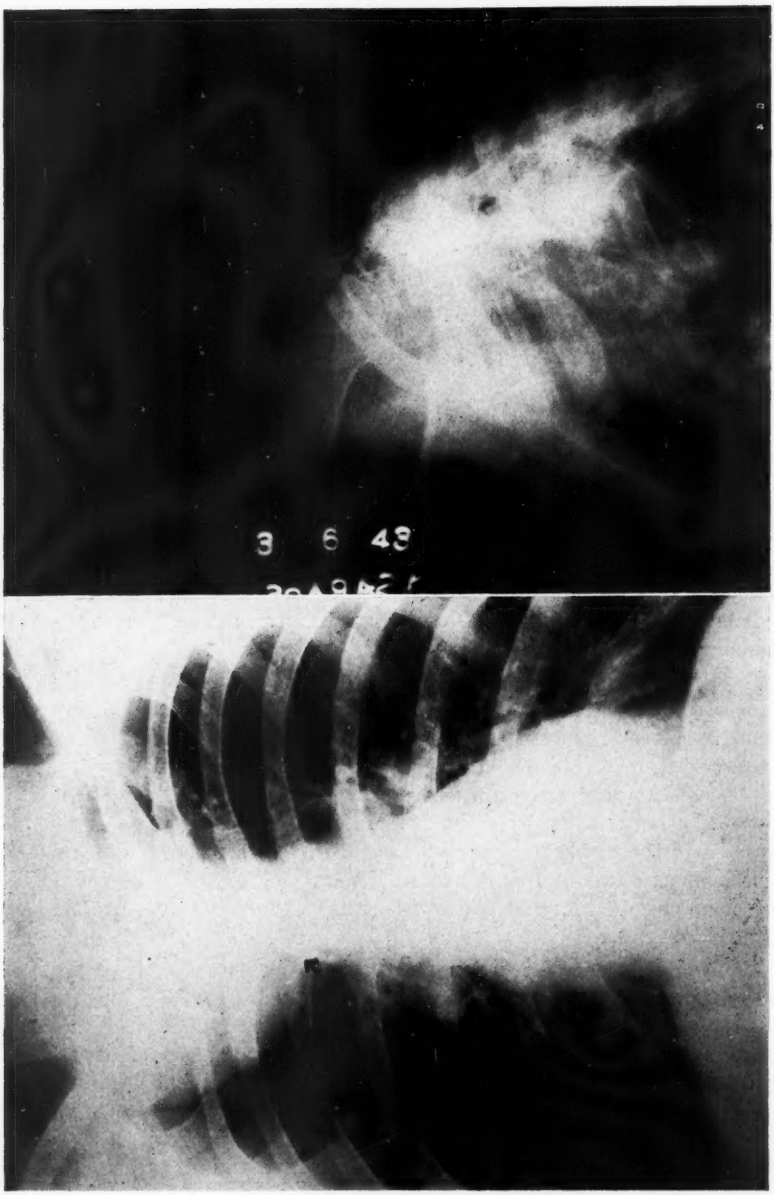
lateral, and overexposed roentgenograms be made (preferably a Potter-Bucky or Swedish grid being used in the last instance). Any other views which may help to demonstrate the lesion more accurately should be taken, and examination of the esophagus with barium sulfate in order to determine the relationship of the esophagus to the mass should be made in all patients with suspected mediastinal pathology.

At times it is difficult to determine whether the cyst is within the mediastinum or within the lung. Although not necessarily conclusive, certain factors are of definite assistance in locating the cyst. When a pleural reflexion onto the mass can be demonstrated (Fig. 1) it suggests that the mass originates in the mediastinum. When the posteromesial pleural line, which is best visualized on the overexposed view, is changed in contour from its normal appearance,[4] a mediastinal tumor may be suspected. Definite localization may be made in many instances after the introduction of air into the pleural cavity, which procedure, if there are no adhesions, will show whether the mass lies within the lung or the mediastinum. Masses which are surrounded by air-containing lung can be readily located without additional studies. Iodized oil bronchography may be of value in locating lesions within the lung and giving further information concerning the adjacent bronchi. It must be borne in mind, however, that in a few cases even the surgeon and the pathologist are unable to determine whether the tumor arises within the lung or mediastinum; and under such circumstances the roentgenologic examination cannot be expected to do so.

Mediastinal Cysts.—A cyst arising within the mediastinum is usually visible as a smooth, round, or ovoid mass, and may be located in any portion. A very common location is beneath the carina and attached to the trachea or main bronchi. If the mass is attached to the trachea, the attachment may be readily demonstrated by having the patient swallow during fluoroscopy (Fig. 2). In some instances, there is attachment to the esophagus. Masses located in the esophageal wall are identifiable as intramural extramucosal lesions.[9] (Fig. 3). A bronchus may communicate with the cyst allowing air and fluid to accumulate within it (Fig. 4).

Certain points of difference in the types of mediastinal tumor are known. Bronchiogenic cysts are smooth and round (Fig. 5), whereas dermoid cysts and teratomas are usually slightly lobulated. Often there is calcification in the wall of a dermoid cyst. This latter type of tumor, when it occurs within the chest, is located in the anterior mediastinum in the majority of cases. A neurogenic tumor on the other hand, although also having a configuration similar to a bronchiogenic cyst, is more frequently found in the posterior mediastinum and may cause erosion of the ribs. Malignant tumors, such as sarcoma, cannot be definitely differentiated roentgenologically from benign tumors, and this of itself makes surgery a practical necessity. Malignant lymphomatous lesions



B.

A.

Fig. 1 (Case 3).—The pleural reflection from the mass in the right superior mediastinum was demonstrated anteriorly in the lateral view (*B*) and at the inferior and mesial margin in the posteroanterior projection (*A*).

are as a rule lobulated, and more often than not are confined to the glandular or thymic areas. A trial dose of irradiation, which should be given in amounts that will not cause permanent damage to the skin, will often determine the diagnosis.[6] An aneurysm of the aorta may simulate a bronchiogenic cyst. However, the correct diagnosis can be made as a rule by means of careful fluoroscopy, laminagraphy, whereby the mass can be separated from the aorta, or visualization of the aorta by opaque medium.

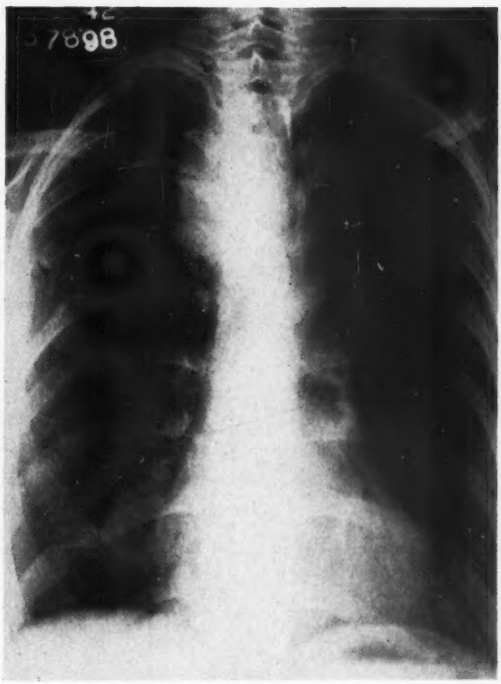


Fig. 2 (Case 5).—The mass in the right superior mediastinum was attached to the trachea and moved during the swallowing act. The mass displaced the esophagus but was not adherent to it. (The right sixth rib had been partially resected for empyema ten years prior to this examination.)

Pulmonary Cysts.—Cysts within the lung, whether congenital or acquired, present a more or less characteristic appearance; they vary in their contents at different stages (Fig. 6). In general, it may be said that the pulmonary cyst like the mediastinal cyst presents a rather round, smooth outline (Fig. 7) with a fluid level readily demonstrated in certain instances. Many cysts, when they contain both air and fluid, have been described as lung abscesses (Fig. 8); others have been thought to represent encapsulated empyema. It is easy to understand why cysts which are filled with fluid but contain no air are confused

with empyema. An important characteristic of the pulmonary cyst is that it is usually confined to one lobe, or a segment of a lobe, and that there is little or no inflammatory change in the adjacent lung.

A tuberculoma may resemble a bronchiogenic cyst, but it is usually smaller, contains no air, and in some instances may demonstrate a flecky area of calcification. Tuberculomas are located more frequently in the upper lobes, whereas bronchiogenic cysts are seen more often in the

Fig. 3 (Case 6).—The small round mass in the lower portion of the mediastinum was attached to the wall of the esophagus and formed an intramural, extramucosal tumor.

lower portions of the lung field. Carcinoma in the periphery of the lung as a rule is demonstrated roentgenologically as a lobulated or flame-shaped area. Rarely, it, or other tumors within the lung, may appear as a sharply defined shadow similar to a bronchiogenic cyst, but the clinical findings and the previous history usually furnish the additional data necessary for final diagnosis.

SURGICAL TREATMENT

As the diagnosis of bronchiogenic cyst is principally roentgenographic so its treatment is surgical. For the following obvious reasons com-

plete operative removal is preferable to exploration, incomplete removal, marsupialization, or drainage. The cyst is out; the diagnosis is made certain; the operation is usually easy technically and is safe; the after-care is little or none; the patient is entirely rehabilitated. The surgical approach to a bronchiogenic cyst is, of course, governed by the age and general condition of the patient, as well as by the location of the cyst, and the possible presence and degree of infection in it. Table I lists the latter factors, together with operative treatment and end results in our series.

TABLE I

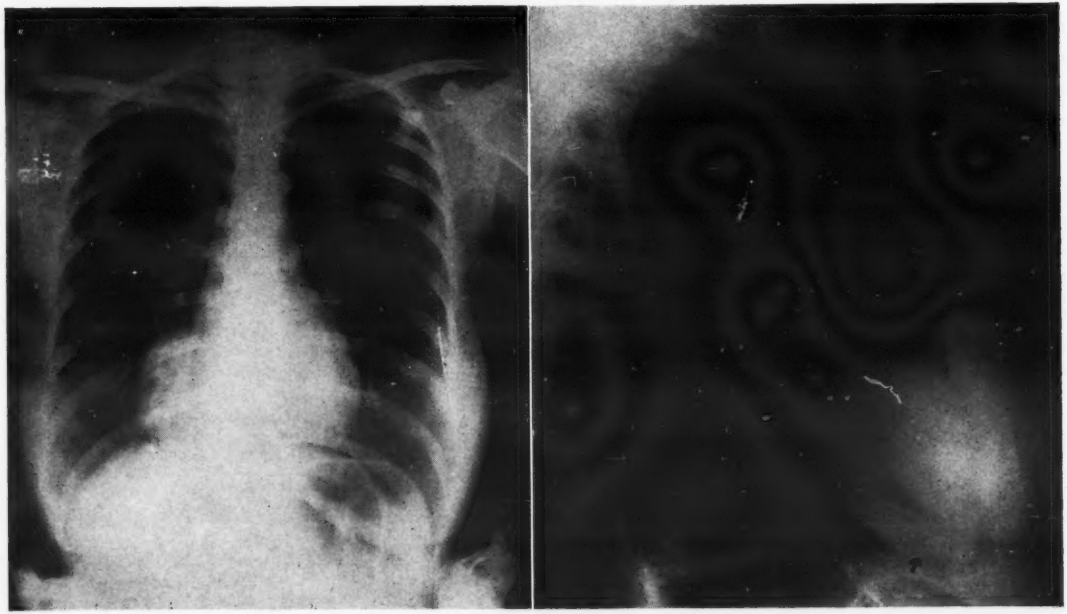
LOCATION OF CYST	ORIGINAL STATE	OPERATION PERFORMED	RESULT
Mediastinum (12 cases)	Clean (10 cases)	Total removal (Cases 1-7)	7 All well
		Partial removal (Case 8)	1 Well
		Aspiration (Case 9)	1 Chronic empyema
		Thoracoscopy (Case 10)	1 Well
	Infected (2 cases)	Removal after drainage (Case 11)	1 Well
		Marsupialization (Case 12)	1 Still draining, 6 yr. (2 revision operations)
Lung (9 cases)	Clean (2 cases)	Segmental lobectomy (Case 13)	1 Well
		Lobectomy (part of cyst wall left behind) (Case 14)	1 Well
	Infected (7 cases)	Lobectomy (Cases 15 and 16)	2 Well
		Dissected from lobe (Case 17)	1 Well
		Lobectomy after drainage (Cases 18 and 19)	2 Well
		Drainage (Case 20)	1 Still draining 15 mo.
		Attempted lobectomy (Case 21)	1 Dead

Mediastinal cysts, if uninfected, are usually easy to dissect and remove. Of the intrapulmonary cysts, one was dissected from lung tissue; the remainder were removed by partial or total lobectomy. In no case was total pneumonectomy required. This point is important. In dealing with nonmalignant conditions of lung, uninvolved, functioning lung tissue must be preserved. Total pneumonectomy, although often much easier technically, should not be resorted to. Churchill and Klopstock[3] and Blades,[2] in discussing other pulmonary diseases, emphasize this principle.

Two of the cysts which were infected at the time of operation were removed in one stage without severe complications. Three of the infected group were removed after preliminary drainage. All five patients are cured of the disease, while two in whom only drainage was done have persistent disease of six years' and one year's duration, respectively. These epithelium-lined cavities with chronic low-grade suppuration can be expected to drain indefinitely unless removed. Destruction of the epithelial lining by chemical cauterization may be possible but it has not been tried by us.

A. *B.*

Fig. 4 (Case 11).—The air- and fluid-containing mass arose from the mediastinum and was attached to the right lower lobe bronchus with which it communicated.



A. *B.*

Fig. 5 (Case 2).—The smooth oval mass in the right anterior cardiophrenic angle demonstrates the usual configuration of a bronchiogenic cyst.

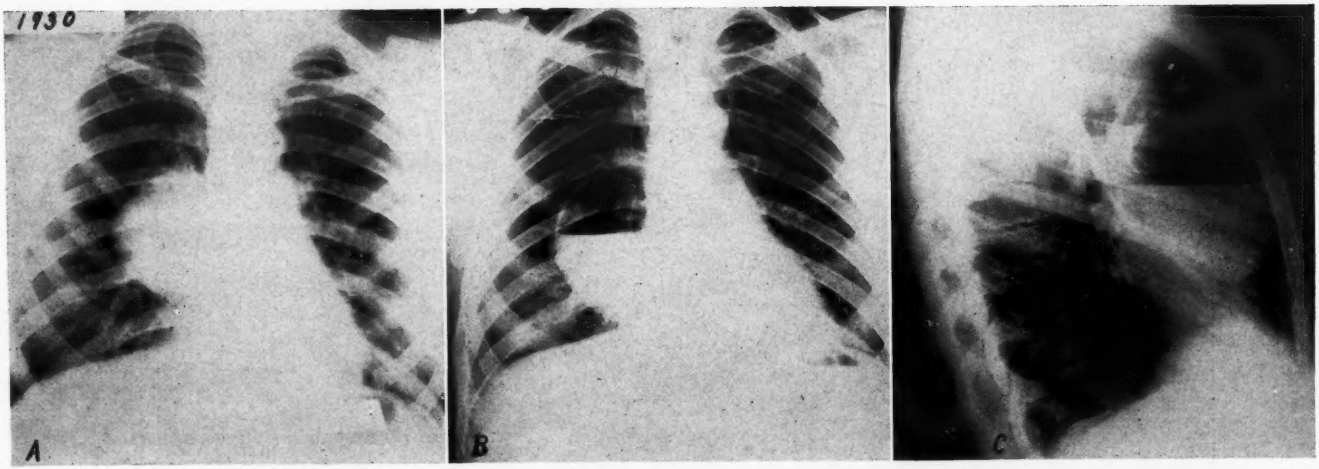


Fig. 6 (Case 17).—*A*, Examination in 1930; a homogeneous mass was seen in the region of the right hilum. *B* and *C*, Examination in 1939; the cyst contained air and fluid.

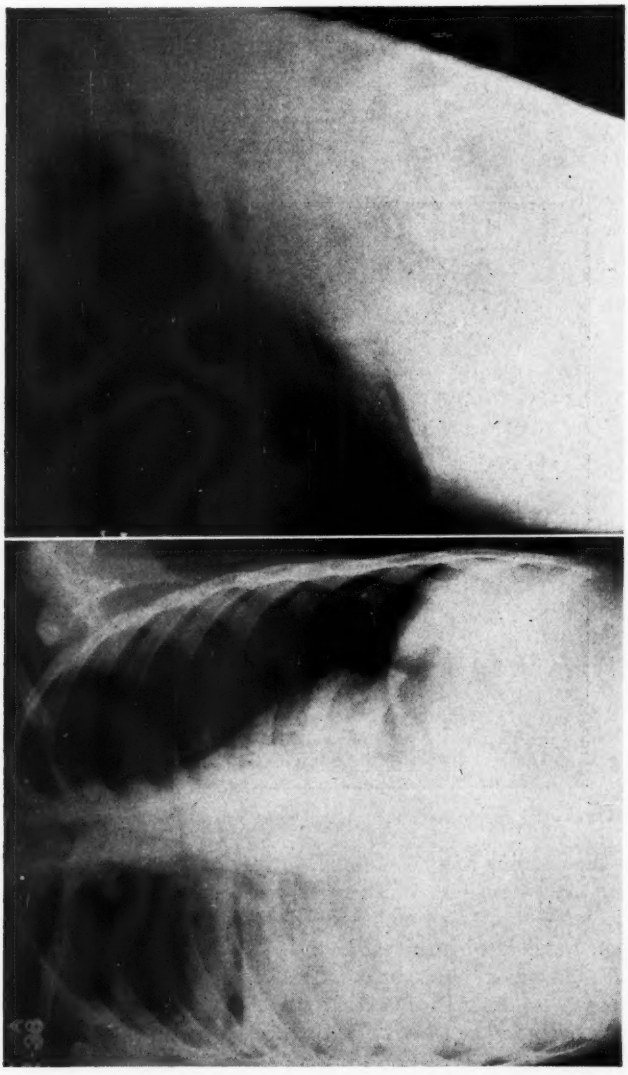
All operations in which the chest was opened were carried out under intratracheal oxygen ether anesthesia, with provision for positive pressure and for aspiration of bronchial secretions as needed.

In the cases where lobectomy, or partial lobectomy, was carried out, postoperative drainage was established in most cases for two or three days to provide for drainage of the chest fluid and operative pneumothorax, and to facilitate re-expansion of the remaining lobes. In patients with infection, or in cases where contamination took place, drainage following lobectomy was maintained for longer periods of time.

Fig. 7 (Case 13).—The round mass behind the heart was entirely within the lung.

Sulfonamide therapy was used as an adjunct to operation in seven of the cases. As a rule, sulfadiazine was given by mouth, started forty-eight hours before operation and continued after operation. In some cases it was administered intravenously. In adults the dose was 6 Gm. daily. Sulfanilamide crystals, sprinkled at the site of operation, were used in a few instances. Chemotherapy is of help in preventing postoperative empyema, or at least in making it less severe.

Postoperative complications were few. One patient had a simple pneumothorax, which was relieved by a single aspiration. One tension pneumothorax was relieved by aspiration. Three patients developed serous effusions, relieved by one or more aspirations. Two patients developed empyema which healed after adequate open drainage. Case 11 is of interest in that the infected cyst was opened and allowed to



A. *B.*

Fig. 8 (Case 16).—The air- and fluid-filled cyst in the posterior portion of the right lower lung field could easily be confused with a lung abscess except that there is relatively little reaction in the adjacent lung.

drain into the pleural cavity, which in turn was drained by a closed catheter. After this empyema had subsided, clean lobectomy was done without complication. In one case empyema occurred several months after an exploratory operation in which only evacuation of the cyst by needle was done. Although the cyst contents had been sterile on culture the late empyema probably arose from the cyst. In five cases temporary lobar atelectasis was noted.

There was one death (Case 21). This patient, operated on in 1934, and chronologically the first of the series, died of overwhelming pneumonia, apparently aspiration type. In more recent patients, with similar lesions, operation has been successful, due both to improved technique and to chemotherapy.

Concomitant congenital abnormalities were found in two patients. In the first (Case 15), an artery arose from the thoracic aorta, running into the independent basal segment of the left lower lobe, in which the cyst lay. In the second patient (Case 13), two large veins, apparently tributaries of the pericardiophrenic vein, ran from the site of the cyst in the basal segment of the left lower lobe to the dome of the diaphragm (Fig. 9). This patient also had a hernia of the posterior leaf of the left diaphragm, apparently the cause of his symptoms.

PATHOLOGY

Certain questions are raised regarding the pathologic diagnosis in these cases. We believe that the cysts here described represent congenital malformations of bronchial or tracheal origin. Those located in the mediastinum are certainly congenital. Their bronchial origin is questionable in some cases. Those in the lung might have resulted from long-standing lung abscess in which there had been adequate bronchial drainage and minimal surrounding inflammatory changes. It is unlikely that such cysts, however, would be lined with columnar ciliated epithelium unless they were congenital. Cysts containing air under pressure (pneumatoceles) and lesions of obvious inflammatory origin were not included in this series.

Of the mediastinal group, the cysts in Cases 1, 5, 6, 7, 11, and 12 were bronchiogenic without question, showing lining of columnar ciliated epithelium. Cartilage plates and mucous glands in the wall confirmed the origin of these lesions. Fig. 10 demonstrates all of these elements. In Cases 2, 3, 4, and 8 the cysts lay in close proximity to the airways or communicated grossly with the trachea or a bronchus. These facts led us to classify them as bronchiogenic, although from the pathologic standpoint they must be called simple cysts, possibly pleural or pericardial. In Cases 9 and 10 no tissue was removed at operation, but the gross appearance of the cysts and the nature of the aspirated contents were typical of bronchiogenic cysts.

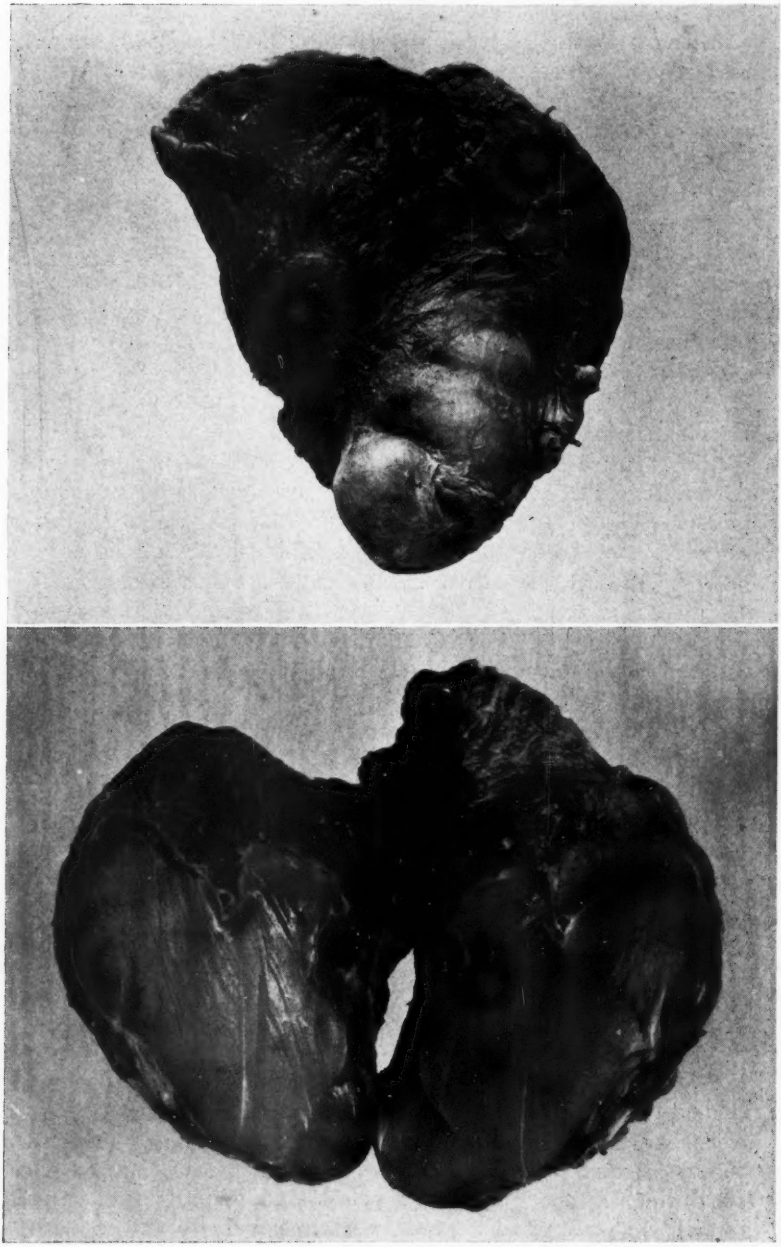


Fig. 9 (Case 13).—Resected basal segment of the left lower lobe. Beside the cyst are seen the ligated stumps of the two anomalous veins encountered in this lobe.

Of the intrapulmonary group, seven of the cysts had histologically demonstrated epithelial lining (Cases 13, 14, 15, 16, 18, 20, and 21). In Cases 19 no cilia were demonstrated, but the relatively slight surrounding inflammation argued for a congenital rather than inflammatory origin. In Case 17 a cystic, uninfected lesion had been known to be present for six years. The more recent secondary infection of these cysts led the patient to seek treatment. Although unfortunately no histologic section was available, we considered this cyst to be bronchiogenic and not an old lung abscess.

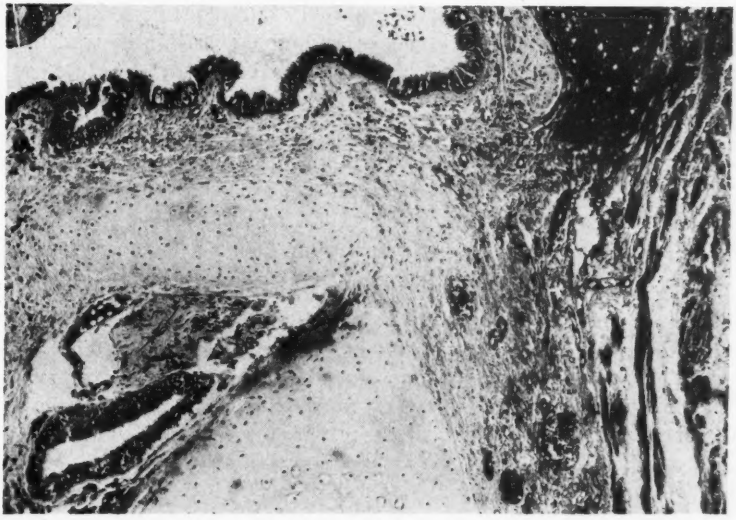


Fig. 10 (Case 7).—Section through wall of cyst, showing ciliated columnar epithelium, cartilage plates, and mucous glands.

SUMMARY

Twenty-one cases of bronchiogenic cyst of mediastinum and lung are presented.

Diagnosis of these cysts is roentgenologic. Characteristically they present smooth contoured, round or ovoid, masses without surrounding inflammatory shadows. The present state of roentgenography does not permit, in all instances, differentiation between benign and malignant lesions of the chest and mediastinum.

Treatment is surgical. It consists of operative removal, which with present improved technics of anesthesia and surgery, is feasible and safe. Resection should be carried out as soon as the cyst is recognized even though clinically asymptomatic. Delay until the appearance of symptoms increases the operative risk because symptoms usually indicate infection within the cyst. Delay is also dangerous because pre-

operative differentiation between benign and malignant lesions is impossible.

Figs. 1*A*, 2, 3, 4, 5, 6, and 8 in this communication are used with the permission of the American Journal of Roentgenology and Radium Therapy.

CASE REPORTS

CASE 1 (U-401331).[8]—A male, aged 18 years, entered the hospital because of the incidental roentgenologic finding of an 8 by 6 cm. right hilar mass. At operation the cyst was found to lie in the mediastinum below the right hilum beneath the phrenic and vagus nerves, attached to pulmonary vessels, right bronchus, and esophagus. In its wall there was a U-shaped piece of cartilage near the bronchus. The cyst was removed completely. Its fluid content was pearly gray, viscid, and sterile on culture. *Histopathology:* The wall of the cyst contained cartilage plates and mucous glands; lining was columnar ciliated epithelium. The patient received sulfadiazine by mouth postoperatively. Two subsequent chest taps produced 850 and 150 c.c. of sterile fluid. The patient was discharged well twenty-nine days after operation.

CASE 2* (U-121816).[8]—A woman, aged 34 years, entered the hospital because of right chest pain of one month's duration. Roentgenogram showed an 8 by 5 by 6 cm. mass in the right anterior cardiophrenic angle. At operation the cyst was found adherent to pericardium but not communicating with it. The cyst was easily dissected and removed; the chest was closed without drainage. *Histopathology:* Pseudostratified, cuboidal epithelium lined one portion of the cyst wall. No sulfonamide was used. The patient was discharged well on the eleventh postoperative day.

CASE 3† (U-394942).[8]—A man, aged 30 years, entered the hospital because of the incidental roentgenologic finding of an 8 by 10 cm. rounded, right upper posterior mediastinal mass. Roentgenoscopically, the mass moved on respiration and was observed to change in shape with change in posture. At operation a pink, thin-walled cyst was found, lying against the trachea, vagus nerve, and esophagus, in the angle between the azygos vein and superior vena cava. It was removed by sharp dissection. The chest was not drained. No sulfonamide was used. *Histopathology:* Cuboidal epithelium lined the cyst. The patient was discharged well, with the wound healed, eleven days after operation.

CASE 4‡ (U-246015).[8, 9]—A man, aged 42 years, entered the hospital because of a cough of two years' duration, productive of not foul but

*This case appeared also in case reports of Massachusetts General Hospital, Case No. 28422, New England J. Med. 227: 606, 1942.

†Case Reports, Massachusetts General Hospital, Case No. 29161, New England J. Med. 228: 516, 1943.

‡Case Reports, Massachusetts General Hospital, Case No. 26291, New England J. Med. 223: 105, 1940.

green sputum, and chest pain of one month's duration, relieved by lying prone. Roentgenogram showed a 10 cm., round mass in the posterior mediastinum with transmitted pulsation, apparently more to the left of the midline and lying under the tracheal carina. At operation the left lower lobe was found to be atelectatic. A large cyst presented between the aorta and the left lung. Muscularis of the esophagus was spread out over the cyst which lay directly on the undersurface of the esophageal mucous membrane. The cyst was very adherent at the tracheal carina, and a fibrous cord here was thought to represent the origin of the cyst. *Histopathology:* No epithelial lining was apparent. The wall was composed of dense fibrous tissue with clusters of lymphocytes, the content, yellow fluid, glistening with cholesterin crystals. No sulfonamides were used. Three postoperative sterile taps were done. The patient was well twenty-six months after operation.

Case 5* (U-357898).[8]—A woman, aged 36 years, entered the hospital because of aching left chest pain with slight exertional dyspnea, of three months' duration. Roentgenogram showed an 8 by 5 cm. mass attached to right posterior margin of the trachea, displacing trachea to left. At operation, after separating the right lung from the mediastinum, the cyst was found to be lying in the retropleural space. It contained thick, yellowish, nonodorous sterile fluid. The cyst was removed and the pleura closed. Sulfanilamide was used locally; the chest was not drained. *Histopathology:* The lining was composed of ciliated respiratory epithelium with cartilaginous plates and mucous glands in the wall. Two thoracenteses were done postoperatively to aspirate air. The patient was discharged well on the twenty-third postoperative day.

Case 6 (U-159525).[8, 9]—A female, aged 25 years, entered the hospital because of nausea and increasing regurgitation of six months' duration. For the previous two months she had been able to eat strained food only. Roentgenologic examination disclosed a 3½ cm. round mass lying in the posterior mediastinum at the level of the eighth dorsal vertebra, with a pressure defect on the esophagus but no break in the esophageal mucosa. The mass moved with the esophagus during swallowing. The patient received a small amount of roentgen therapy with no change in the size of the mass by roentgenogram. Transpleural operation was carried out through a posterolateral approach. The cyst was found to lie within the muscularis of the esophagus; it was carefully dissected free, and the chest closed without drainage. *Histopathology:* The lining was made up of respiratory ciliated epithelium with smooth muscle, mucous glands, and cartilage in the wall of the cyst. The patient made a good recovery. One chest tap for air and fluid was done postoperatively.

*Case Reports, Massachusetts General Hospital, Case No. 28412, New England J. Med. 227: 560, 1942.

CASE 7 (U-55476).[8]—A woman, aged 62 years, entered the hospital because of severe epigastric pain radiating to the back, of twenty-five years' duration. Radiation was sometimes substernal. The patient had had two gall bladder operations, a gastroenterostomy, and later a laparotomy for undoing the gastroenterostomy. Roentgenogram showed a rounded shadow behind the heart, apparently a posterior mediastinal tumor. There was also a small gastric hiatus hernia. A balloon introduced through the esophagus to a point one inch above the diaphragm and dilated with air produced pain in the epigastrium and midline similar to the usual attacks, with radiation toward the throat. It was believed, therefore, that the hiatus hernia might be the cause of the patient's symptoms. At operation a pedunculated tumor was found hanging from the region of the ninth and tenth vertebral bodies. Several branches of the thoracic sympathetic nerve trunk were seen to course over the tumor. The tumor was easily removed. The hiatus hernia was repaired with silk. *Histopathology:* The cyst wall contained mucous glands and cartilage plaques. Lining was made up of columnar ciliated epithelium. No sulfonamides were used. The patient was discharged well thirty-six days after operation.

CASE 8* (U-56685).[8]—A man, aged 67 years, entered the hospital because of fifteen years of epigastric pain with some dysphagia. Roentgenogram showed a lobulated mass in the right anterior mediastinum close to the heart. At operation, through an anterior approach across the pleura, a large cyst was found and enucleated. A second cyst above it, running upward, was evacuated, and the chest was closed without drainage. *Histopathology:* The cyst was lined with flattened endothelium-like cells. The patient was discharged well fifteen days after operation.

CASE 9 (U-96804).[8]—A woman, aged 67 years, entered the hospital because of occasional epigastric pain of three months' duration and incidental roentgenologic findings of a mass in the chest. Roentgenogram showed a 9½ by 6 cm. oval, dense area in the right midlung field, apparently in the interlobar septum. At operation the chest was entered through the third right interspace anteriorly. At the medial aspect of the upper lobe was a rounded cystic mass adherent to the lung and the mediastinum. The phrenic nerve was displaced forward on its anteromedial aspect. The cyst was tapped and thick mucinous fluid obtained. Because it was deemed impossible to remove the cyst without undue risk, its contents were evacuated and the chest closed without drainage. Postoperatively, there was apparent collapse of the lower half of the right lung. Three taps disclosed no pleural fluid. Three years later the patient developed empyema which drained for

*Case Reports, Massachusetts General Hospital, Case No. 23492, New England J. Med. 217: 958, 1937.

one and one-half years. The chest has remained healed for the subsequent eighteen months. The patient has no pain, but occasional cough and expectoration.

CASE 10 (U-252157).—A man, aged 36 years, entered the hospital because of pain in the left chest and dyspnea. Roentgenogram showed left pneumothorax and a smooth, rounded mass projecting from the upper mediastinum into the left chest posterior to the trachea and esophagus. Bronchoscopy disclosed a normal bronchial tree. Thoracoscopy (under local anesthesia) showed above and slightly posterior to the aorta a smooth, rounded, pearly gray mass which appeared to be a cyst. Two or three attempts at aspiration produced nothing but blood. It was thought that the mass was a benign bronchiogenic cyst and therefore resection was not advised.

CASE 11 (U-354989).[8]—A man, aged 32 years, first entered the hospital because of intermittent cough, expectoration, and hemoptysis present for one and one-half years, with foul sputum for two months before admission. Roentgenogram showed a 10 by 8 cm., oval-shaped mass with a fluid- and air-containing cavity in the medial upper portion of the right lower lobe. Bronchoscopy showed foul secretion coming from the right main bronchus. Two-stage drainage procedure was proposed, but at the second stage it was found that abscess was separated from the parietal pleura by a layer of clean, thin fluid 2½ cm. deep. This wound was packed, and nineteen days later thoracotomy was carried out. The cyst on the mediastinal aspect of the right lung was opened and emptied, but could not be marsupialized. Dissection was technically impossible; therefore, the cyst was left open to drain into the pleural cavity and the pleural cavity drained externally. No bronchial fistula was apparent after this procedure.

Three months later the patient was readmitted for operation with the chest wound healed but foul expectoration continuing. Upon opening the chest through the bed of the sixth rib a large cyst was found, intimately adherent to the lower lobe, extending beneath the carina, occupying the whole lower mediastinum behind the heart, adherent to the lower esophagus and lower lobe bronchus with which it communicated. The cyst was dissected free, the lower lobe bronchus was transected and sutured, the lower lobe artery and vein separately ligated, and the lobe and cyst removed. *Histopathology:* The cyst was lined with columnar ciliated epithelium with mucous glands in the wall. The patient was given sulfadiazine postoperatively and the chest healed after drainage for twelve days. He was discharged well on the thirty-second day, and has remained well more than one year after operation.

CASE 12 (U-85892).[8]—A man, aged 33 years, had had three bouts of vomiting, chest pain, and expectoration in the previous six years. Roentgenogram showed a 9 cm. smooth, rounded mass arising in the right

posterior mediastinum. At operation the cyst lay between the base of the heart and esphagus. There was dense, surrounding inflammatory reaction. One-half of the cyst wall was resected and the remaining cavity marsupialized to the pleura and extrapleurally in the paravertebral area. *Histopathology:* The cyst was lined with high columnar ciliated epithelium. Four months later a second operation was done to establish wider dependent drainage. After another thirteen months, a third revision of drainage was carried out. Six years after the original operation the cyst was reported to be still draining.

CASE 13* (U-392955).—A man, aged 51 years, entered the hospital because of substernal present pain for four years. He had had a slight cough, productive of mucus and on one occasion blood, for one year. Roentgenogram showed a 4 cm., round mass behind the heart on the left diaphragm with partial collapse of the left lower lobe. Barium demonstrated herniation of cardia of the stomach through the posterior leaf of the diaphragm. At operation, the hernia, which was separate from the esophageal hiatus, was easily reduced and repaired by imbrication with silk sutures. In the left lower lobe was a 3 cm. smooth, rounded gray mass with two large, thick-walled veins running from it into the diaphragm (See Fig. 9). The basal segment of the left lower lobe, containing the cyst, was removed, with ligation of the pulmonary vessels and suture of the bronchus. *Histopathology:* There were cartilage plates in the cyst wall and the epithelium was columnar and ciliated. Convalescence was complicated by persistent lower lobe collapse and fever. Three months after operation the patient was well, however, and free from pain and cough.

CASE 14 (U-343755).[8]—A male, aged 26 years, developed spontaneous pneumothorax after carrying a deer for several miles. This was relieved by aspiration of air, but roentgenogram showed a large air-filled cavity of the right middle lobe, and patient was referred for operation. On opening the chest, a huge pneumatocele was found. It was deflated and opened. Within it at its root lay a smaller air-filled cyst, apparently communicating with the bronchus and leaking air through a tiny perforation. This small bronchiogenic cyst was apparently the cause of the pneumatocele and resulting tension pneumothorax. Middle lobectomy by individual ligation technique was carried out, but portions of the cyst wall, which were adherent to the upper and lower lobes, had to be left behind. The pleural cavity was drained for forty-eight hours with an inlying catheter, and two subsequent chest taps produced sterile fluid. *Histopathology:* Ciliated respiratory epithelium lined the smaller cyst. The patient was discharged well, with wounds healed, twenty-two days after operation.

*Case Reports, Massachusetts General Hospital, Case 29401, New England J. Med. 229: 595, 1943.

CASE 15 (U-45833).—A male, aged 21 years, entered the hospital because of intermittent cough and foul expectoration for six years. Roentgenogram showed a mass in the left lower lung field with several cavities and fluid levels. At operation the posterolateral segment of the basal division of the left lower lobe was found to be an independent lobe with well-developed fissures. This lobe, containing the infected cyst, was removed and the chest drained. Local sulfanilamide and sulfadiazine by mouth were used. *Histopathology:* The cyst was lined with columnar ciliated epithelium with mucous glands and cartilage plates in the wall. The drain was removed after twenty-four days, and the sinus healed promptly. The patient was well and free of symptoms fourteen months after operation.

CASE 16 (U-11534).[8]—A boy, aged 12 years, entered the hospital because of a foul productive cough of five months' duration; onset was shortly after tonsillectomy. Roentgenogram showed uniform dullness in the right posterior chest with fluid level. The process was considered to be lung abscess and was drained in one stage. Bronchial fistula persisted. One year later the patient was readmitted, and a right lower lobectomy carried out, using tourniquet technique. *Histopathology:* The cavity was lined by stratified columnar epithelium with very little surrounding inflammatory reaction. Almost complete absence of scar tissue suggested congenital cyst rather than abscess. Postoperative drainage of the pleural cavity was maintained for three weeks, clean healing ensuing. The patient was discharged well, free from symptoms.

CASE 17 (U-169510).[8, 10]—A male, aged 18 years, entered the hospital because of cough and nonfoul expectoration for one year. Yearly roentgenograms for the previous six years, taken as part of a tuberculosis survey, had shown a right upper lobe shadow relatively unchanged in size. On entry this roentgen shadow appeared as a thin-walled cavity against the right side of the heart in front of the right main bronchus, containing fluid and air with a shifting level. Iodized oil injected intrabronchially did not enter the cavity. At operation the bronchiogenic cyst was dissected from the right upper lobe. No chemotherapy was used. Postoperative empyema required open drainage. The patient subsequently made a complete recovery.

CASE 18 (U-372335).—A male, aged 16 years, entered the hospital for treatment of a draining chest wound. Two years previously, because of fever and malaise, he had been in another hospital where roentgenogram showed a round mass in the left mid-chest. Diagnosis of infected left upper lobe cyst without bronchial communication was made, and the cyst was drained. One year later pneumonectomy was attempted but abandoned. On entry here, there was a 3 cm. opening in the left chest wall with bronchial fistulas in its depth. Iodized oil bron-

chogram showed normal left lower lobe bronchial tree and drained cyst of the upper lobe. At operation sinus was excised and upper lobectomy carried out by individual ligation technique. Local sulfanilamide and sulfadiazine by mouth were used. The chest was drained. *Histopathology:* The cyst was lined with columnar ciliated epithelium. Postoperative empyema with bronchial fistula required open drainage. Empyema finally healed seven months later. Fifteen months after operation, the wounds were healed and the patient was well.

CASE 19* (U-13924).[8]—A female, aged 24 years, first entered the hospital because of productive cough for two months, beginning with a cold. There was no history of foreign body. Roentgenogram showed a large rounded cavity containing fluid in the posterolateral left side of the chest, moving with the diaphragm. This lesion was drained by two-stage procedure. *Histopathology:* The cavity wall had epithelial lining of flat and cuboidal cells. Thirty-four months later the patient was readmitted and the left lower lobe resected in a two-stage procedure, tourniquet technique. The chest was drained for six weeks postoperatively. Following removal of the drainage catheter, the sinus healed completely. The patient was well and symptom-free four years after operation.

CASE 20 (U-383558).[8]—A woman, aged 51 years, entered the hospital because of recurrent bouts of cough and foul expectoration with fever. Roentgenogram showed an 8 by 10 cm. rounded mass apparently arising from the right upper posterior mediastinum, not attached to the esophagus. The patient was obese and acutely ill. At operation a pus-filled cyst in the right upper lobe was emptied, biopsied, and marsupialized. *Histopathology:* The lining was composed of columnar ciliated respiratory epithelium. With the tube in place, the cyst has continued to drain thin mucopus. The patient is well and active and has gained forty-five pounds, but has occasional slight cough with expectoration of brown material. Mapping with iodized oil shows a residual 5 cm. cavity. It is expected that permanent drainage will have to be maintained unless total operative removal later becomes feasible.

CASE 21 (gh-341857).[8]—A male, aged 19 years, entered the hospital because of intermittent hemoptysis of three years' duration. There was no foul sputum or dyspnea. Roentgenogram showed a sharply defined, rounded area of density in the right upper lobe. Bronchoscopic examination was negative. At operation the upper lobe was found to be densely adherent. After the adhesions were freed and the interlobar septum partially developed, the patient's condition became poor, and operation was terminated. Air and serosanguineous fluid were aspirated from the chest postoperatively, but the patient died on the third day

*Also published by Churchill, E. D.: Lobectomy and Pneumonectomy in Bronchiectasis and Cystic Disease, J. THORACIC SURG. 6: 286, 1937.

with a temperature of 108° F. At autopsy there was bronchopneumonia of both lungs and in the right upper lobe, and a 10 c.c. cyst, lined with ciliated columnar respiratory epithelium.

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THORACOPLASTY AND CONTRALATERAL PNEUMOTHORAX IN BILATERAL PULMONARY TUBERCULOSIS

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IN A certain group of tuberculous patients bilateral pneumothorax, although highly desirable, is technically impossible. These patients often either are denied collapse therapy or are treated only unilaterally. Thoracoplasty for the otherwise untreated lesion, in conjunction with a contralateral pneumothorax, is usually considered unwise for technical reasons, and valueless because of the final results. This study has been undertaken to determine the desirability of thoracoplasty in the presence of a contralateral pneumothorax and to analyze the immediate and late results of this form of combined therapy.

To accomplish this: (1) Our patients' lesions have been classified in each lung at the time when pneumothorax and thoracoplasty were begun. (2) The surgical complications and their effect on the results have been tabulated. (3) The follow-up as related to control of disease and return to gainful occupation has been recorded.

TABLE I

CLASSIFICATION OF DISEASE IN EACH LUNG AT THE ONSET OF THERAPY

CLASSIFICATION	THORACOPLASTY	PNEUMOTHORAX
Minimal	0	1
Moderately advanced without cavity	1	6
Moderately advanced with cavity	3	10
Far advanced without cavity	1	0
Far advanced with cavity	38	27
Unknown	1	0
	44	44

Our series is comprised of 44 unselected consecutive patients having a unilateral pneumothorax, upon whom 174 thoracoplasty stages have been performed for the lesions in the lung opposite to the pneumothorax, or an average of 3.9 stages per patient. All patients had positive sputum on smear or concentrate examination at the time thoracoplasty was begun.

In general, the thoracoplasty was delayed until the lesions beneath the contralateral pneumothorax gave satisfactory evidence of progressive improvement. In 25 out of 30 patients there was regression of the lesions with closure of existing cavities on the side of the pneumothorax. In the other 5 cases the cavities were smaller and the prog-

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ress of the disease indicated probable eventual closure. Serial roentgenograms showed the disease to be stationary on the pneumothorax side in 14 cases at the time the thoracoplasty was begun. The duration of pneumothorax treatment before thoracoplasty was begun is shown in Table II. In one instance the pneumothorax had been present for seven years.

TABLE II

DURATION OF PNEUMOTHORAX BEFORE THORACOPLASTY

TIME	CASES
1 to 3 Mo.	7
3 to 6 Mo.	5
6 to 12 Mo.	7
1 yr. or more	25

McIndoe, Steele, Samson, Anderson, and Leslie state that tuberculous tracheobronchitis is an important complication in approximately 11 per cent of the reinfection type of pulmonary tuberculosis. In a series of 622 tuberculosis cases, Salkin, Cadden, and Edson report an incidence of 15.5 per cent of tracheobronchitis. Fifteen, or 34 per cent, of our 44 patients exhibited tuberculous laryngotracheobronchial lesions in some form. Three of these 15 patients had laryngeal tuberculosis only, while in the remaining 12, the bronchi were involved. Six of the 15 patients, or 40 per cent of those showing this complication, died. Two of these 6 patients had laryngeal tuberculosis only. In only 3 cases did the tuberculous laryngitis or bronchitis seem to be directly contributory to the death of the patients.

The complications occurring during the stages of the thoracoplasty have been separated into those complicating the thoracoplasty and the underlying lung, and those related to the contralateral pneumothorax (Table III).

TABLE III

COMPLICATIONS

PNEUMOTHORAX		THORACOPLASTY		
Spontaneous pneumothorax	6	Wound serum		5
Spread of tuberculosis	6	Wound infections:		5
Lost	3	Tuberculous	1	
Abandoned (dyspnea)	1	Deep abscess	1	
Cavity reopened	1	Superficial	3	
Tuberculous pleuritis (serous)	1	Dyspnea		4
		Psychosis		2
		Hemoptysis with spread of tuberculosis		1
		Pain		1
		Thrombophlebitis (anticubital)		1
		Shock		1
		Cerebral embolus		1
Total	18	Total		21

Eighteen complications with the pneumothorax occurred in 13 patients. Immediately before each contemplated thoracoplasty stage the

lung was allowed to expand slightly in order to improve the functional respiratory reserve and, following the operative stage, the degree of collapse was slowly increased to its previous amount or to a degree short of respiratory discomfort. These manipulations may have accounted for some of the complications.

The complications encountered in this combined form of therapy are not different from those encountered in either form of therapy alone, although the incidence of these complications was probably considerably higher. These complications occurred with almost equal incidence on the pneumothorax and the thoracoplasty sides. They were of sufficient magnitude to interrupt the planned collapse program in 13 of the 44 patients. Six of these 13 patients are now dead.

In only 13 cases was the planned program abandoned; the reasons are listed in Table IV. Among the 13 patients whose program was interrupted because of these complications, 6 are now dead, 2 are improved, and 5 are in sanatoriums, unchanged.

TABLE IV

COMPLICATIONS REQUIRING DISCONTINUATION OF THORACOPLASTY

COMPLICATIONS	CASES
Dyspnea	4
Spread of tuberculosis under pneumothorax	3
Psychosis	2
Hemoptysis with spread of tuberculosis under thoracoplasty	1
Cerebral embolus	1
Tuberculous wound infection	1
Tuberculous pleuritis (serous)	1
Total	13

Since it is assumed, at the time the thoracoplasty is begun, that the pneumothorax will control the lesions in the contralateral lung, the satisfactory therapeutic management of this group of cases and all like it must necessarily hinge upon the treatment of the lung upon which a satisfactory pneumothorax cannot be obtained. If a thoracoplasty collapse is sufficient to close the cavity and control the noncavernous lesions of the lung on which thoracoplasty has been done, the patient obviously is in a more favorable condition for being cured. The immediate conversion of the sputum, although it frequently occurs, cannot be used solely to judge when sufficient collapse has been obtained from the thoracoplasty. The x-ray appearance of the lesion together with the physical examination of the chest, especially palpation of the decostalized portion of the hemithorax, are valuable guides as to attainment of optimal collapse for the present and future security of healing of the particular lesions. These guides were used as criteria in this series of cases to determine when the thoracoplasty was completed. As supplementary measures, all patients were given postural exercises (lying on the side on which thoracoplasty had been done, across a rolled pillow

placed beneath the axilla for six to eight hours a day) and wore a pressure pad below the clavicle most of the day in order to maintain or improve the collapse until the chest wall had stiffened. The postural exercise also helps to correct or prevent scoliosis until the decostalized part of the thoracic wall becomes firm.

Since the immediate results are only important in determining whether or not this form of combined therapy can be carried to completion, immediate sputum conversion and cavity closure have not been tabulated. The value of combined thoracoplasty and pneumothorax is best judged by the condition of the patients and their course after the completion or interruption of the thoracoplasty.

The 44 patients in this series have been followed for one year or more since the last stage of the thoracoplasty. Thirteen patients are dead, 17 patients are in sanatoriums, and 14 patients are now at home.

The early mortality rate (within three months) for the entire group was 6.8 per cent and the late mortality rate 22.7 per cent, an overall total mortality rate of 29.5 per cent. The causes of death in the 13 patients who did not survive are listed in Table V. The causes of death

TABLE V

CAUSES OF DEATH IN ENTIRE SERIES

COMPLICATION	CASES
Pulmonary spread	3
Progressive dyspnea and cardiorespiratory failure	3
Cardiac	3
Generalized tuberculosis	1
Embolic	1
Pontocaine reaction before bronchoscopy	1
Unknown	1
Total	13

as listed are those usually encountered in the surgical treatment of pulmonary tuberculosis, the one exception being the death due to pontocaine anesthesia in a patient being prepared for bronchoscopy. In Table VI is given the length of life from the date of the last thoracoplasty stage until the death of the patient.

TABLE VI

DURATION OF LIFE FROM LAST STAGE OF THE THORACOPLASTY TO DEATH

TIME	CASES
0 to 1 Mo.	1
1 to 3 Mo.	2
3 to 6 Mo.	2
6 to 12 Mo.	1
12 to 18 Mo.	1
18 to 24 Mo.	3
2 to 3 Yr.	1
3 to 4 Yr.	1
4 or more yr.	1
Total	13

In the entire series of 44 patients there was a sputum conversion in 20 (45.5 per cent) and closure of all cavities under the thoracoplasty (including those in whom the thoracoplasty could not be completed) in 33 patients (75 per cent). In 37 patients cavities were present prior to the induction of the contralateral pneumothorax. In 31 of these patients (83.7 per cent) all cavities beneath the pneumothorax were closed. When only the living patients were considered, there was conversion of sputum in 64.5 per cent and closure of the cavity under the thoracoplasty in 83.8 per cent. These data appear in detail in Table VII.

TABLE VII

EFFECT OF TREATMENT ON SPUTUM, CAVITY, AND RESPIRATION

	PATIENTS		
	AT HOME	IN SANATORIUMS	DEAD
Sputum			
Smear (positive)	0	7	7
Concentrate (positive)	0	2	3
Culture (positive)	0	2	3
Negative	14 (100%)	6 (35.3%)	0
Cavity under thoracoplasty			
Open	0	5	6
Closed	14 (100%)	12 (70%)	7 (36.8%)
Cavity under pneumothorax*			
Open	0	3	3
Closed	11 (100%)	14 (82.3%)	6 (66.6%)
Dyspnea			
Slight	5	4	
Moderate	0	5	
Severe	0	0	
None	9 (64%)	7 (41%)	
Unknown	0	1	

*In seven additional patients pneumothorax was induced for noncavernous lesions.

In the 31 living patients, it was possible to continue the pneumothorax in 16, or 51 per cent (Table VIII), while in 10 patients, at home, the pneumothorax was no longer present. In six of these it was voluntarily abandoned after apparent healing had occurred.

TABLE VIII

STATUS OF PNEUMOTHORAX IN CONTRALATERAL LUNG

	PATIENTS			
	AT HOME	IN SANATORIUMS	DEAD	TOTAL
Continued	4	12	6	22
Discontinued	10	5	6	21
Unknown	0	0	1	1

In Table IX is listed the duration of sanatorium care of those patients later followed at home. The time is computed from the date of the last thoracoplasty stage until discharge from the sanatorium. Each

patient was followed sufficiently long in the sanatorium to be certain that, although the disease was bilateral, it was well under control.

TABLE IX

POSTOPERATIVE SANATORIUM STAY OF PATIENTS FOLLOWED AT HOME

TIME (MO.)	PATIENTS
6 to 12	3
12 to 18	5
18 to 24	2
24 to 30	2
Discharged to home*	2

*Patients admitted from home and allowed to return after completion of thoracoplasty.

When tuberculous patients can be discharged from a sanatorium with negative sputum and closed cavities and return to their homes without endangering their family and the members of the community in which they reside, they are being restored to the place in society which their disease caused them to abandon. In order to determine whether these patients are capable of more than minimal activity, a complete follow-up study was done and their present occupations are listed in Table X.

TABLE X

PRESENT OCCUPATION OF DISCHARGED PATIENTS

OCCUPATION	PATIENTS
Light work	3
Regulated exercise (unemployed)	2
Office work	2
Salesman	2
Timekeeper	1
Industrial nurse	1
Housework	1
Unemployed but able to work	1
Farmer	1

From this it may be seen that they are under no greater restrictions than any comparable group of patients with tuberculosis for whom only unilateral collapse therapy has been instituted.

DISCUSSION

Numerous articles have appeared in the literature showing the very poor results of bed rest alone for the treatment of cavernous pulmonary tuberculous lesions. In 1930, Werner and O'Brien reported the results obtained in a group of 100 patients having cavities 3 cm. or more in diameter and receiving only bed rest. There was spontaneous closure of cavity in 14 cases but 6 of these reopened. The average stay in the sanatorium was three years and 40 per cent of the patients died in the institution.

In 1941, Wiese reported a somewhat similar group of patients, with smaller cavities, receiving only bed rest. In this series of 125 patients

with cavities of 4 cm. or less, spontaneous closure occurred in 16 per cent, or 20 of them. Three were discharged with positive sputum.

Many patients when first seen can be confidently told that bed rest will be inadequate and, because of the extent or type of lesions present, they will need the degree of collapse offered by a satisfactory bilateral pneumothorax. Often attempts to follow this program result in only a unilaterally satisfactory pneumothorax. The presence of adhesive pleuritis in the contralateral side prevents the finding of any space for the induction of air, or the presence of unseverable viscero-parietal adhesions results in an inadequate pneumothorax which is often reluctantly continued by the clinician for want of a more satisfactory plan.

As early as 1936, Coryllos and Ornstein reported 87 cases of combined thoracoplasty and pneumothorax as a form of combined therapy in bilateral cavernous pulmonary tuberculosis with an overall mortality rate of 18.4 per cent. Sputum conversion was obtained in 48.2 per cent of all patients. The study of this series of cases extended over a three-year period but the duration of the postoperative follow-up was not stated. Pneumothorax was used in 13 of their cases for diagnostic purposes and its management and continuance were unrecorded. Six patients received pneumothorax after completion of the thoracoplasty because of a contralateral spread of their disease. In all the cases reported in our series, the pneumothorax was present at the time the thoracoplasty was started.

In 1940, Finkelstein and Guggenheim, in a study of the contralateral lung after thoracoplasty, found that 10 of their thoracoplasties had been done in the presence of a contralateral pneumothorax, with 1 death. Spontaneous pneumothorax occurred as a complication in 6 cases. They concluded that if contralateral pneumothorax were thought to be indispensable prior to operation, it should be maintained for one year or more before proceeding to the thoracoplasty.

Diffenbach and Crecca, in reporting 100 consecutive thoracoplasty cases in 1941, cite 41 patients who had a contralateral pneumothorax at the time of thoracoplasty. Among these 41 patients, 5 died and 13 continued with positive sputum. The results in 181 thoracoplasty cases, reported by Meltzer in 1941, included 11 patients on whom the operation was done in the presence of a contralateral pneumothorax. In 72.7 per cent of these cases the sputum became negative. Thompson and Janes strongly advise this form of therapy and report 15 cases in which they have used it with only 1 death.

O'Brien, Tuttle, Day, and O'Connor, in 1938, gave a more detailed report of their experience with this form of therapy. Their series at this time was comprised of 85 cases and is the largest group reported, to date, in which thoracoplasty was used after a pneumothorax had been established on the contralateral side, where there were cavities in 60

per cent of the cases. In this group, 207 thoracoplasty stages were done with an overall mortality rate of 21.1 per cent. Sputum was converted in 68.4 per cent of the living cases. Cavities were closed in 58 of the 76 living patients, or 76.3 per cent.

In the cases herein reported, the preoperative, operative, and postoperative factors which would have any definite bearing upon the response of the patient to this specified form of therapy have been given in detail. In every instance the thoracoplasty was done for far advanced or moderately advanced tuberculosis. Among the 44 patients, a pneumothorax was induced to close existing cavities in 37 patients, while a thoracoplasty was performed to close cavities in 41 patients.

Although the pneumothorax had been carried for more than one year in more than 50 per cent of our cases before the thoracoplasty was begun, this time factor was purely incidental. The thoracoplasty was started whenever there was sufficient serial roentgenographic evidence of the satisfactory progress of the pneumothorax lesions. Despite 17 pneumothorax complications, including 6 spontaneous pneumothoraces, the pneumothorax space was held in 40 of the 44 patients until the primary thoracoplasty had been completed. In 3 instances, in which a secondary thoracoplasty was necessary, it was possible to maintain the pneumothorax without incident.

Any form of collapse therapy may be attended by some degree of shortness of breath. Since thoracoplasty is an irreversible form of therapy, the dyspnea may be permanent and incapacitating. Among the 13 patients whose program was not completed, there were 4 cases in which the combined therapy was abandoned because of dyspnea. These cases might have been eliminated preoperatively from the planned program by studies of individual pulmonary function such as those originally described by Jacobaeus, Frenckner, and Bjorkman and recently recommended by Whitehead and associates, or by the simpler form of bronchospirometry which has proved so helpful to Steele in evaluating similar patients.

In our series, 3 patients died of cardiorespiratory failure. None of the patients living at the time of this communication had a severe degree of dyspnea. Nine of the 17 patients still in sanatoriums had slight or moderate dyspnea but none required oxygen therapy. Twelve of the 14 patients who were at home were employed or capable of employment. Two were still on regulated exercise and their ability to work could not be judged. Five of the 14 patients who were at home complained of slight dyspnea on exertion.

Before discharge from a sanatorium each patient had been observed for a minimum period of six to twelve months after completion of the thoracoplasty and all had negative sputum and closed cavities. Each patient was subjected to progressive, regulated exercise and only if the pulmonary lesions remained unchanged was he permitted to go home.

Among the 17 patients still in sanatoriums at this writing, 6 had negative sputum and 12 had closed cavities. Some of these patients showed a favorable response to their exercise program and will undoubtedly be discharged at a future date. Three of the six patients still having positive sputum have known tuberculous ulceration of their bronchi, while in the remaining three an extensive, exudative type of lesion is present.

SUMMARY

1. Forty-four thoracoplasty patients with pulmonary tuberculosis with positive sputum, upon which 174 operative stages were done, have been reviewed. Each patient had a contralateral pneumothorax at the time the thoracoplasty was begun.

2. Thoracoplasty: On the side of the contemplated thoracoplasty, a cavity was present in 41 instances and in all cases the tuberculosis was far advanced or moderately advanced.

3. Pneumothorax: A cavity was present in 37 cases before the induction of the pneumothorax. In only one instance was the disease minimal at the time of the institution of the pneumothorax. The lesions on the side of the pneumothorax became stationary in 14 cases and there was improvement in 30 cases with complete closure of existing cavities in all but 5, before the beginning of the thoracoplasty.

4. Fifteen, or 34 per cent, of the 44 patients had some degree of tuberculous laryngitis or bronchitis. In 3 patients only the larynx was involved and in 12 patients only the bronchi were involved.

5. In 13 cases the planned thoracoplasty program was not completed because of complications.

6. The early mortality rate (within three months) in this series was 6.8 per cent and the late mortality rate was 22.7 per cent. The total mortality rate was 29.5 per cent. All living patients have been followed for more than one year since the last stage of their primary thoracoplasty.

7. Among the 31 living patients (17 in sanatoriums and 14 at home), there has been conversion of sputum in 64.5 per cent and closure of cavity under the thoracoplasty in 83.8 per cent.

8. Twelve of the 14 patients at home are capable of pursuing a gainful occupation.

CONCLUSION

The performance of thoracoplasty in the presence of a contralateral pneumothorax is desirable and the results justify its more frequent consideration and employment in the treatment of bilateral pulmonary tuberculosis.

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INTRATHORACIC NEUROGENIC TUMORS

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ALL intrathoracic tumors have assumed a more important role in medicine within recent years because of the improvements in diagnosis and the development of thoracic surgery. Those tumors which arise in nerve elements are of special importance since there is a prevailing misconception that they are nearly always benign. Actually we have found in a series of 18 proved cases at the Barnes Hospital that in no less than 7 cases (41 per cent) the tumor should be regarded as malignant on gross and microscopic pathologic findings, and in one other case it was impossible to arrive at a definite decision concerning the malignancy of the tumor. This incidence of malignant tumors in our own experience evidently agrees closely with that of others, for in a collected series of 105 cases from the literature 39 cases (37 per cent) were considered malignant. Geschickter, in 1935, called attention to the high incidence of malignant tumors in primary neoplasms of the peripheral nerves. In 850 primary nerve tumors studied by him and Bloodgood at the surgical pathologic laboratory of Johns Hopkins Hospital there were no less than 350 examples (41 per cent) of malignant neoplasms. In the study no mention is made of any intrathoracic tumors and practically all, if not all, of those included arose in other parts of the body. Our own percentage of malignant tumors among those occurring in the thorax agrees therefore with that found by Geschickter for the body as a whole. But it would seem that those tumors which arise either within or close to the posterior mediastinum are less frequently malignant than those which arise from the chest wall at some distance from the mediastinum.

The most common tumor of the posterior mediastinum or of the posterior part of the superior mediastinum is one of neurogenic origin. In our own series of 18 patients with proved tumors and 3 with presumptive ones (a total of 21 cases), 19 of the tumors were in the posterior part of the thorax and only 2 in the anterior mediastinum. In the series of 101 cases which we have collected from the literature, in only 2 was the tumor located in the anterior mediastinum. The next most

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common tumor of the posterior mediastinum is the much more rare one consisting of elements of bone or cartilage. From a practical diagnostic standpoint, in any case of recognized tumor of the posterior mediastinum the presumption is strong that it is one of nerve origin.

The essential characteristics of the nerve tumors which are found within the thorax do not differ from those of peripheral nerve tumors encountered elsewhere in the body. There is still some uncertainty as to their origin and the many names which have been given to them have increased the confusion. It is generally agreed, however, that the most common tumors originate in the nerve sheath. But regarding which elements of the sheath are the most important, some controversy has occurred. The idea that many of these tumors arise from the Schwann cells is generally attributed to Verocay and has been recently championed by Masson. Penfield, however, stresses the importance of the connective tissue elements as the source. Bailey and Hermann, at one time impressed with the Schwannian theory, have made exhaustive studies upon two cases of multiple tumors of the peripheral nerves and have concluded that such origin of the "common neurinomas and spindle celled malignant tumors of the peripheral nerves is very doubtful." Credit for the connective tissue hypothesis is sometimes given to von Recklinghausen, in 1882, but Fulton has recently called attentio to the fact that Robert W. Smith of Dublin, Ireland, in 1849 described the condition of multiple neurofibromatosis. Virchow, according to Geschickter, in 1863 divided tumors of the peripheral nerves into the true and false neuromas. He considered the latter to originate in the nerve sheath.

Geschickter recognizes two varieties of solitary benign nerve sheath tumors, a differentiated and an undifferentiated group.

> The more highly differentiated tumors are rich in collagen and fibrous tissue and in one or more zones of the tumor a clumping of the nuclei in a characteristic palisade arrangement can be seen. These tumors . . . rarely undergo malignant change. They have been variously termed perineural fibroblastomas, neurinomas, Schwannomas, neurilemmomas, and lemmomas. The tumors of the undifferentiated group may or may not be encapsulated and are prone to recur and to undergo malignant change. The combination of multiple superficial and deep tumors of this type is part of the clinical picture of von Recklinghausen's disease. Histologically these growths are composed of reticulated myxomatous tissue often arranged in bundles and sometimes extremely cellular. These tumors have been variously referred to as fibromyxomas, fibroneuromas, and myxoid neurinomas. Sarcoma of the nerve sheath may arise in either type of solitary nerve tumor.

The tumors which belong to Geschickter's first group, especially those which fall into the category designated by Stout as neurilemmomas, constitute the principal type of nerve tumor encountered within the thorax and their most frequent origin in this region is the intercostal

nerves. Perhaps the next most common type is one characterized by the presence of multipolar ganglion cells. Grossly, such tumors do not differ essentially from the neurilemmoma and the clinical picture of the patient and special studies do not provide differentiation between them. Those tumors revealing numerous widespread ganglion cells are designated ganglioneuromas. If they contain a preponderance of fibrous tissue they are sometimes called ganglioneurofibromas. They are usually considered to have arisen from the sympathetic nervous system. It has been our experience that certain nerve tumors which present the picture of the neurilemmoma may show, in additional sections from other areas, the presence of ganglion cells. Accurate classification, in our opinion, warrants study of multiple zones from this group of tumors.

Some of the primary nerve tumors arise within the intervertebral foramina and they extend both to the spinal canal and outwardly into the posterior mediastinum. They are often called hourglass- or dumbbell-shaped tumors. The possibility of this configuration in all posterior mediastinal tumors which may be of nerve tissue origin must receive careful consideration. Close cooperation between, and joint study by, both the thoracic surgeon and the neurosurgeon should be undertaken to determine the presence of an extension of the tumor within the spinal canal.

The symptoms produced may be of no consequence or they may be more severe and of a sort resulting from involvement of certain nerves. In many instances the tumor has been discovered accidentally by an x-ray examination made for some other reason. In other cases the patients have complained of pain which has been radicular or referred along an intercostal nerve. Other symptoms sometimes present are dyspnea, stridor, unproductive cough, hoarseness with paralysis of a vocal cord, and Horner's syndrome from involvement of the sympathetic chain.

These tumors present a rather definite roentgenologic picture. They are usually single when encountered within the thorax, and since most of them are adjacent to or within the posterior superior mediastinum, they present a sharply circumscribed, nonpulsating, rounded mass in the posterior upper thorax. In some cases there is an associated erosion of the ribs lying adjacent to the mass. A lobulated appearance of the tumor is always suggestive of rapid growth and therefore of malignancy. Otherwise, however, there is no characteristic x-ray finding which justifies a diagnosis of malignancy unless metastases can be demonstrated. Even the demonstration of the presence of a pleural effusion does not justify an assumption of malignancy. Harrington had a case in which there was bloody fluid even before operation although the tumor was subsequently proved to be benign. A diagnostic test dose of radiation therapy is of little or no value in establishing

a diagnosis of malignancy because the neurogenic tumors, even the malignant ones, are but little affected.

The only effective treatment for intrathoracic nerve tumors is surgical removal. Because of the high incidence of malignant change it is wise to remove these tumors as soon as the diagnosis is made unless there are other reasons for not advising an operation. The operative approach is planned according to the position of the tumor to be removed. Since the majority of the tumors are in the posterior mediastinum, a posterior approach is used most frequently. If the patient has an hourglass tumor it is preferable to remove both the intraspinal and intrathoracic parts at the same operation. If, however, such extensive surgery should be contraindicated at one stage, the intraspinal portion should be the point of attack.

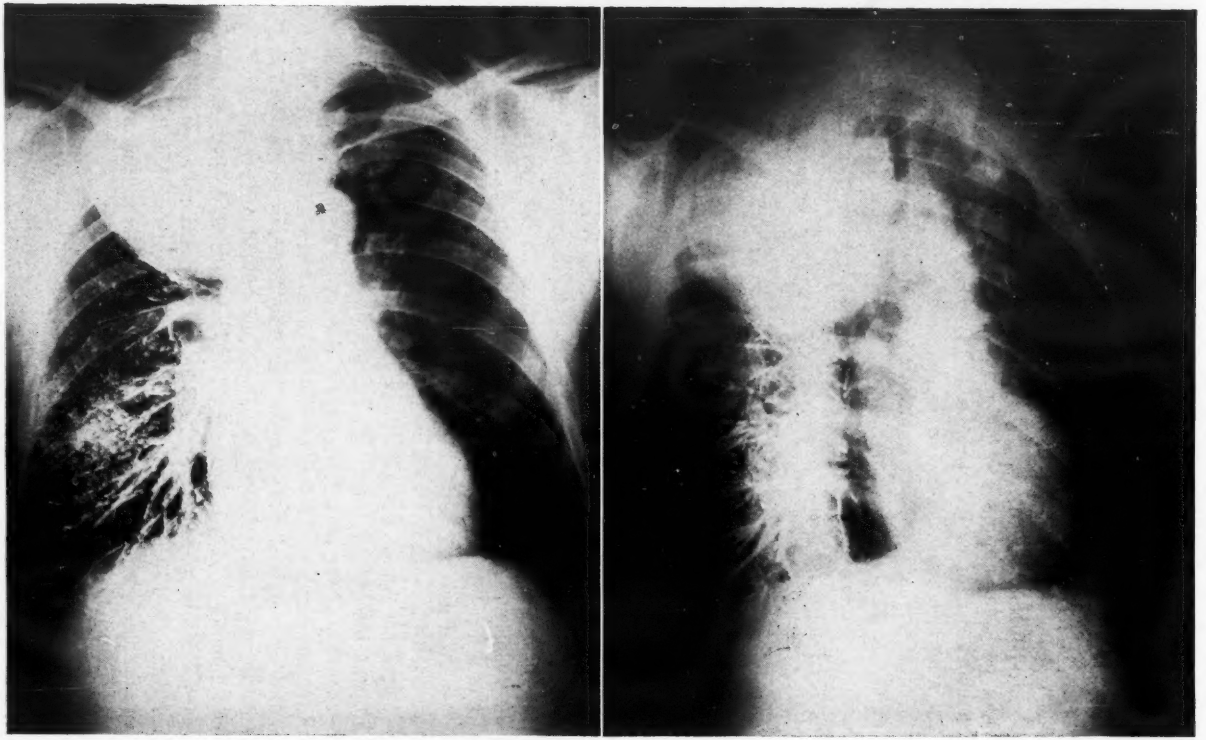
Abstracts of our own 18 proved and 3 probable cases of intrathoracic neurogenic tumors follow:

CASE REPORTS

CASE 1.—A 44-year-old white man was admitted to Barnes Hospital, Oct. 6, 1936. He gave a history of having had a routine chest x-ray examination, required by his employer, which revealed a mass in the upper right chest. Physical examination was essentially negative. X-ray pictures of the chest revealed a large, sharply circumscribed tumor in the right upper posterior mediastinum (Fig. 1, *A* and *B*). Fluoroscopy revealed no expansile pulsation of the mass and roentgen therapy did not affect the size of the tumor. Operation was performed, Oct. 24, 1936, and through an anterolateral approach the tumor, about the size of a large orange and obviously a thin-walled cystic growth, was easily removed and no pedicle was demonstrated. The chest wall was reconstructed in anatomic layers without drainage of either the pleural space or the superficial wound. Convalescence was uneventful and the patient was discharged thirty days after operation, at which time a roentgenogram of the chest (Fig. 1, *C*) revealed complete re-expansion of the right lung. Follow-up of this patient was continued for four years and he remained symptomless and free from any evidence of recurrence during this period, in which he had gained forty pounds.

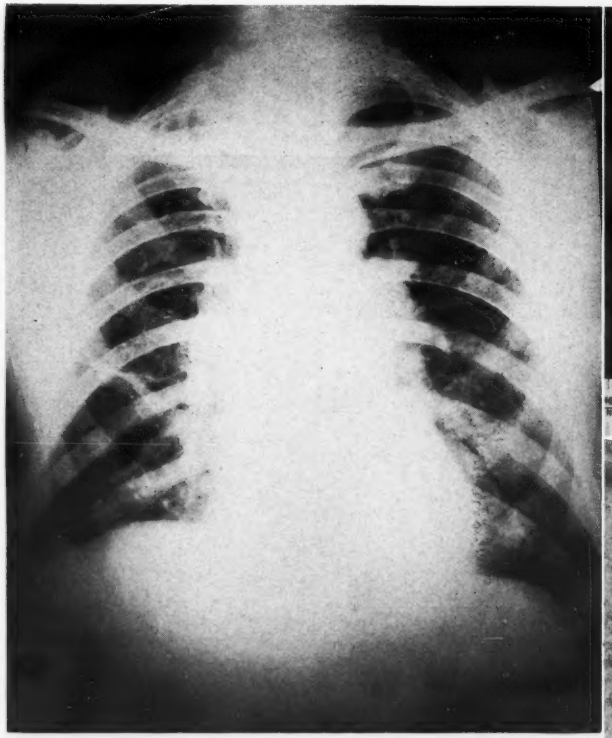
The tumor (Fig. 1, *D*, after fixation) was a thin-walled cyst and microscopic study (Fig. 1, *E*) revealed fibrous and collagenous connective tissue in which enormous numbers of large nerve bundles could be found. The content of the cyst was clear, yellow, thin fluid. A diagnosis of neurilemmoma with cystic change was made.

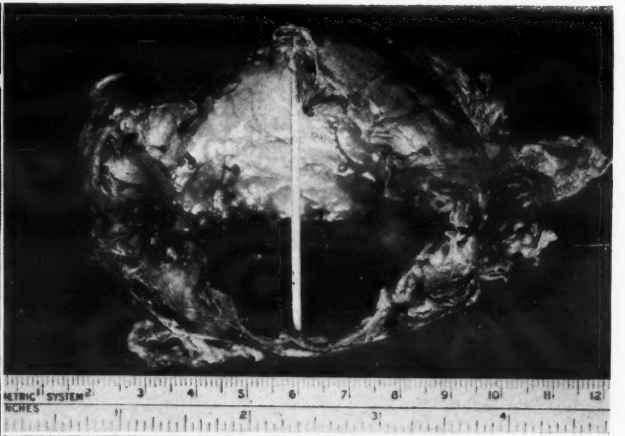
CASE 2.—A 58-year-old white man was admitted to Barnes Hospital, Oct. 21, 1926, with a complaint of very severe pain in the left shoulder and upper chest. This pain had been present for three years and had constantly increased in intensity. Physical examination of the chest revealed an area of impaired resonance with decreased breath sounds

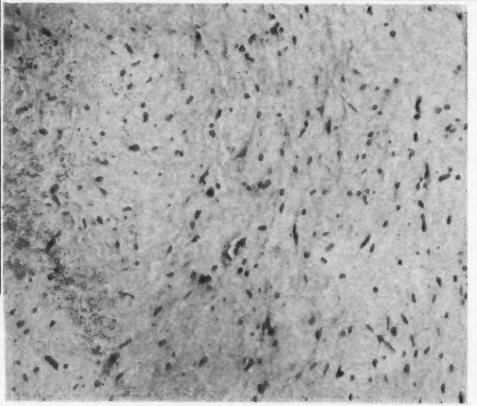


A. *B.*

Fig. 1.—*A*, The sharply outlined tumor can be seen in the right upper thorax. Lipiodol bronchography indicates the extrapulmonary nature of the mass. *B*, The oblique view reveals the posterior position of the tumor.

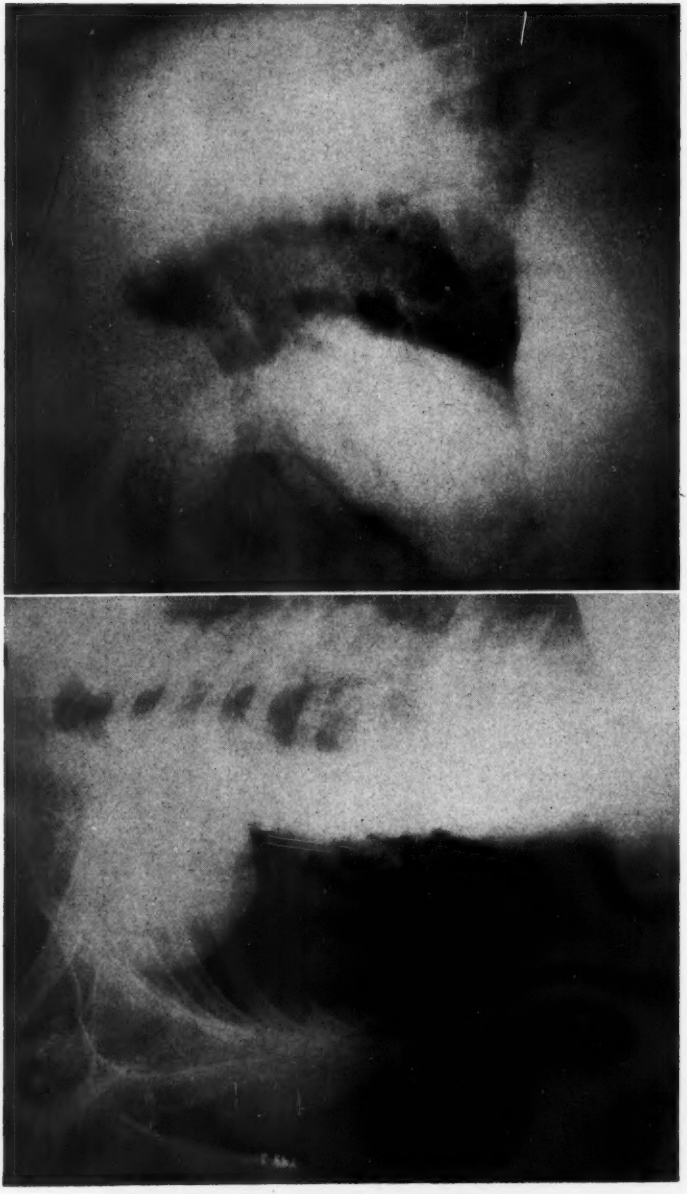






C. *E.* *D.*

Fig. 1.—*C*, Roentgenogram of the chest one month after removal of the tumor. *D*, Photograph of the fixed gross specimen. Note cystic character. *E*, Photomicrograph of section from tumor.



B.

A.

Fig. 2.—*A*, Oblique view of chest revealing clear-cut tumor mass. *B*, Lateral view, same chest.

D.

C.

Fig. 2.—*C*, Photograph of fixed specimen. Note cystic character. *D*, Photomicrograph of section from specimen.

over the left upper, posterior chest. There were sensory changes over the cutaneous distribution of the left ulnar nerve. Routine laboratory findings were negative. X-ray examination of the chest revealed a large, clearly demarcated mass in the left upper posterior mediastinum (Fig. 2, *A* and *B*). Fluoroscopy did not reveal expansile pulsation of the mass. Operation was performed, Oct. 25, 1926, through a left posterolateral approach. The tumor was about the size of a large grapefruit situated in the posterior upper mediastinum and extended more into the left hemithorax than the right. The mass was firmly adherent to the vertebral bodies and the left posterior chest wall, and a line of cleavage was found with great difficulty. Just as the excision was being completed a serious hemorrhage occurred. Bleeding was stopped after the loss of a large quantity of blood, but the patient failed to rally in spite of emergency measures to combat shock from loss of blood. An autopsy was performed.

The tumor, which had been removed at operation, was found to be of firm consistency although it contained numerous multiloculated cysts (Fig. 2, *C*). Microscopic examination revealed the typical picture of neurilemmoma (Fig. 2, *D*).

Case 3.—A 21-year-old white female was admitted to Barnes Hospital, April 8, 1936, with the complaint of pain in a mass on the right chest wall. About one year before, a lump had been noticed on the upper right posterior aspect of the chest and about six months before admission the onset of pain occurred and had persisted. Roentgen therapy had been administered before admission but there had been no effect upon the mass. Physical examination revealed scattered areas of pigmentation of the skin. Over the sixth and seventh ribs posteriorly there was a palpable tumor. X-ray examination of the chest revealed a posterior mediastinal mass on the right with erosion of the bodies of the fifth and sixth dorsal vertebrae plus marked erosion of the posterior portion of the seventh rib. On the left side the roentgenogram revealed another tumor overlying the ninth rib posteriorly, accompanied by erosion of the rib at the posterior axillary line. The neurologic examination was without significant change at this time. Operation was performed on the tumor in the left chest, April 13, 1936. The mass accompanied the ninth left intercostal nerve which was itself enlarged three times the average diameter. The mass actually was comprised of three separate but closely associated tumors. The tumor was completely excised along with almost the entire length of the ninth left intercostal nerve. Microscopic examination revealed an encapsulated tumor composed of spindle-shaped cells and round cells. There was considerable myxomatous change in many areas. No nerves were seen running through the tumor except the thickened trunk of the ninth intercostal nerve which formed a sort of core in the tumor masses. Convalescence was

uneventful. Diagnosis was neurilemmoma of the ninth left intercostal nerve.

The patient was readmitted to Barnes Hospital, July 6, 1936, with a spontaneous fracture of the tenth left rib and two days later it was resected along with the tenth left intercostal nerve which was greatly thickened. The microscopic picture was similar to that seen in the ninth nerve.

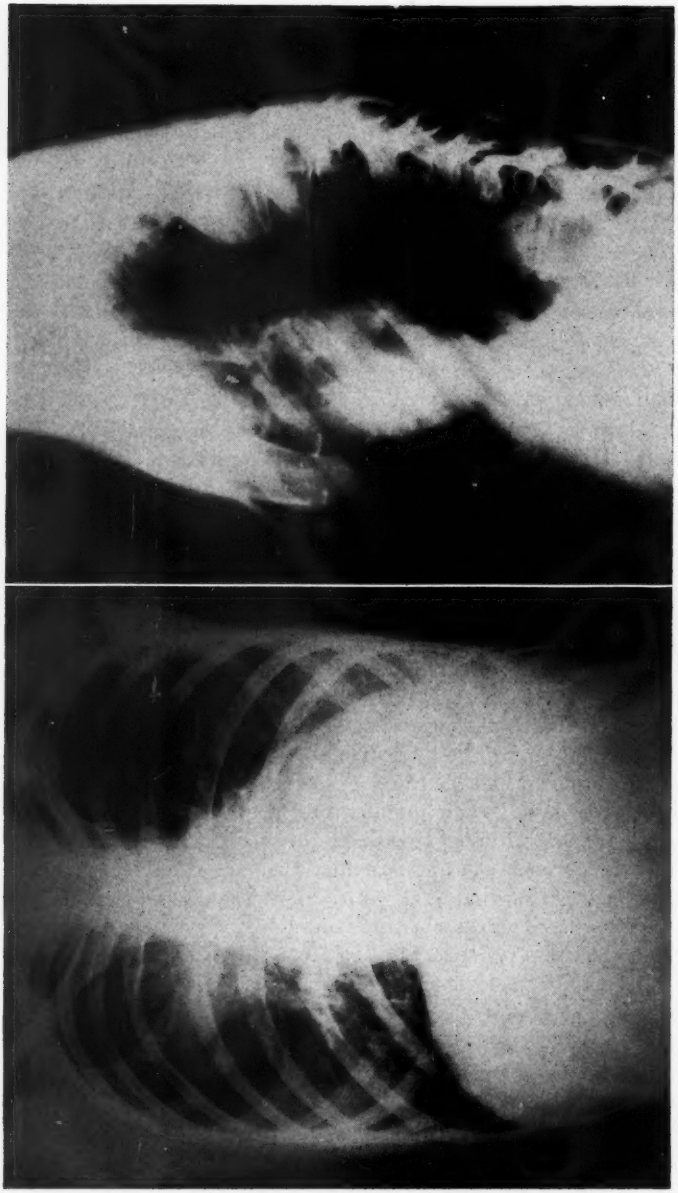
The third admission to Barnes Hospital occurred Sept. 29, 1936, and was made for the purpose of removal of the right posterior mediastinal mass. The x-ray study of the chest made at this time confirmed the previous observations, namely the presence of the posterior mediastinal mass accompanied by pressure erosion of the adjacent portions of the sixth and seventh ribs (Fig. 3, *A* and *B*). Operation was performed, Nov. 1, 1936, and the tumor was grossly similar to the others, but was larger and accompanied the sixth right intercostal nerve. The mass was removed without difficulty and the patient was discharged from the hospital ten days later. A chest roentgenogram taken at this time (Fig. 3, *C*) revealed entire removal of all visible tumors without deformity of the thoracic cage.

Microscopic study of the specimen (Fig. 3, *D*) revealed a picture not unlike that seen in the previously removed tumors except that in this specimen there were some suggestions that the tumor might not be benign, namely extreme cellularity and definite variations in the size and the shape of nuclei.

The patient was readmitted to Barnes Hospital, Jan. 11, 1938, with neurologic signs of partial compression of the spinal cord. Laminectomy was performed by Dr. Ernest Sachs, Jan. 15, 1938, and an hourglass tumor was revealed which had destroyed the laminas of the fifth and sixth dorsal vertebrae. Both the intraspinal and the mediastinal portions of the tumor were removed, which, upon microscopic study, were considered to represent neurosarcomatous changes. Convalescence was once more uneventful, but follow-up information revealed that the patient developed complete block of the spinal canal just above the operative level. This was discovered in May, 1938, and the patient died of infection of the urinary tract on July 7, 1938.

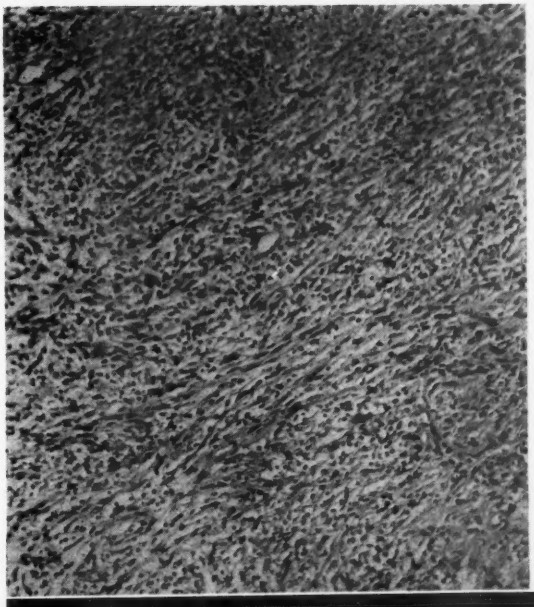
At autopsy there were found greatly enlarged spinal nerves which were associated with numerous nodular masses. A large tumor at the level of the fourth dorsal vertebral segment had caused erosion, compression of two adjacent vertebral bodies, and complete obstruction of the spinal canal. The post-mortem examination was performed elsewhere and a final diagnosis of fibrosarcoma of primary nerve origin was made.

This case history provides a demonstration of multiple tumors of peripheral nerves with examples of intrathoracic, mediastinal, and



A. *B.*

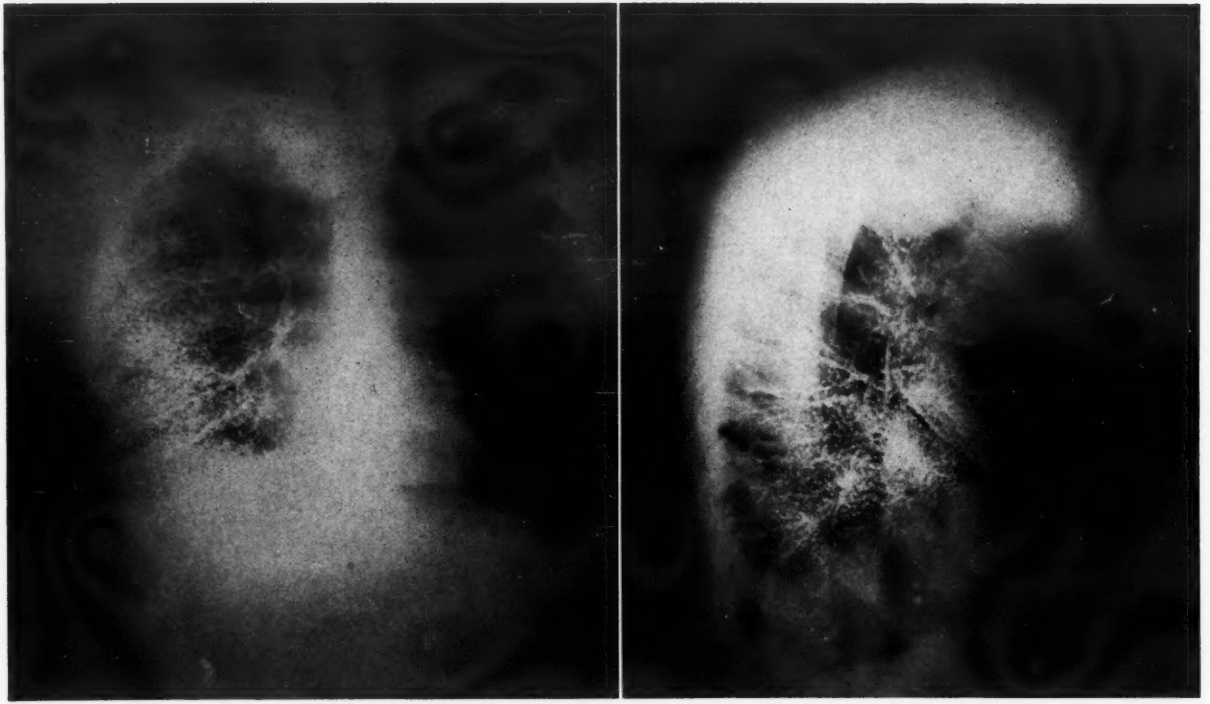
Fig. 3.—*A*, Roentgenogram of chest revealing tumor in right upper thorax. *B*, Lateral view of chest showing posterior position of tumor.



D.

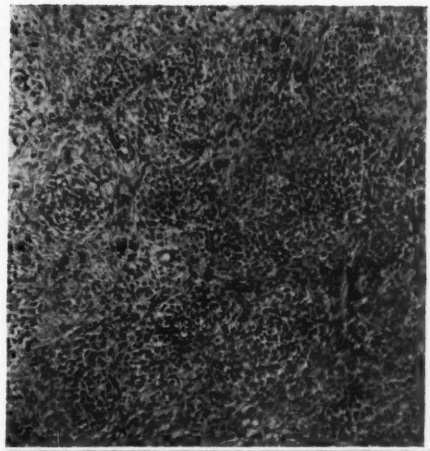
C.

Fig. 3.—*C*, Roentgenogram of chest after removal of tumor. *D*, Photomicrograph of section from tumor specimen.



A. *B.*

Fig. 4.—*A*, Roentgenogram of chest revealing tumor mass in right upper chest. Lipiodol bronchography demonstrates extrapulmonary character of mass. *B*, Lateral view of same chest.



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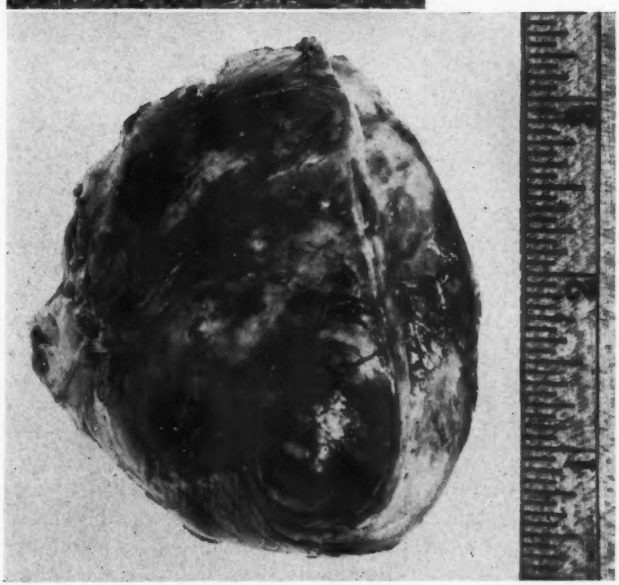


C.

Fig. 4.—*C*, Gross specimen after removal. *D*, Photomicrograph of section from tumor.

hourglass lesions undergoing malignant changes in a single patient. The fatal outcome resulted from cord compression.

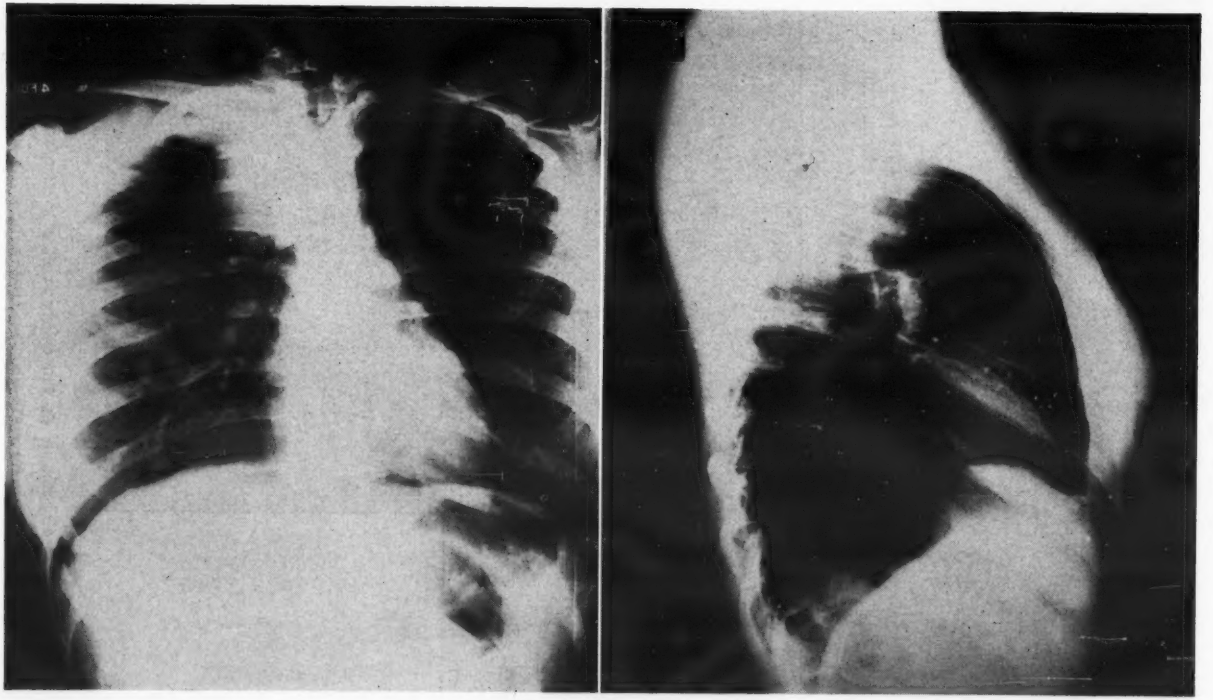
CASE 4.—A 39-year-old white man was admitted to Barnes Hospital, Dec. 20, 1939, with the complaints of pain in the right arm for three years, weakness and vague malaise for one year. Physical examination revealed muscular weakness in the right arm, increased skin temperature of the right upper extremity, a right-sided Horner's syndrome, and hoarseness of the voice. Examination of the chest revealed impaired resonance and decreased breath sounds over the apical area of the right chest. Routine laboratory studies, serology, and the electrocardiograph tracing were normal. Roentgenograms of the chest revealed an apical tumor in the right hemithorax. This mass was clearly outlined, and when bronchograms were prepared with lipiodol the mass could be shown to be not of pulmonary origin (Fig. 4, *A* and *B*). Fluoroscopy and laminographs contributed no additional information.

Operation was performed Dec. 23, 1939, through a posterior approach. A firm yellowish tumor was found at the apex of the right thoracic cavity (Fig. 4, *C*). The sympathetic chain could be followed over the surface of the mass and interruption of its fibers had been brought about by traction attenuation as could be clearly seen. The tumor was enucleated without great difficulty and the wound was closed with reconstruction of anatomic planes.

Microscopic study of the tumor revealed the picture associated with neurilemmoma. However, it was considered to be a malignant tumor because of great numbers of nuclei throughout the tumor, variety in size, shape, and staining characteristics, giant nuclei, and the presence of mitotic figures (Fig. 4, *D*).

The postoperative course was uneventful for thirty-six hours, but during the night of the second day the patient suddenly developed critical respiratory distress and died in less than three minutes. Autopsy permission was not obtained and the cause of death remains obscure.

CASE 5.—A 19-year-old white female was admitted to Barnes Hospital, May 10, 1939. She gave a history of paresthesias on the right side of the neck, a nonproductive but persistent cough, and dyspnea upon exertion, all of two years' duration. For eighteen months there had been pain in the right upper posterior chest and weakness of the right upper extremity. An intrathoracic tumor had been diagnosed elsewhere four months before admission and roentgen therapy had been administered with no response. Physical examination revealed impaired resonance and distant breath sounds over the right apex, diffuse swelling of the subcutaneous tissues over the right upper posterior chest wall, and dilation of the subcutaneous veins of the right upper extremity and over the right upper chest. There were no neurologic findings. The right upper extremity was of greater diameter than the left and there was a brawny feel of the skin. Roentgenograms of the chest revealed

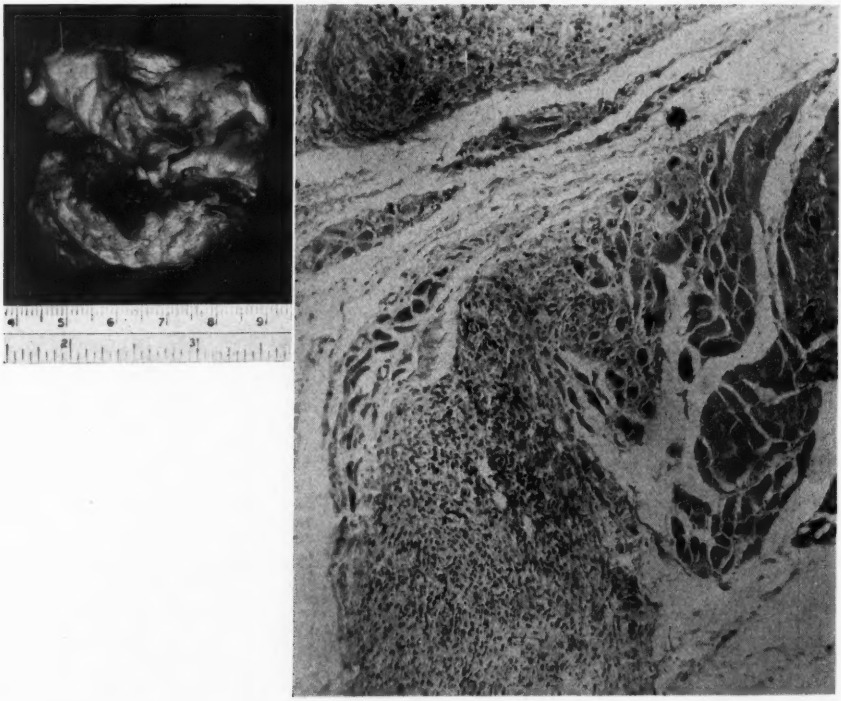


A. *B.*

Fig. 5.—*A*, Roentgenogram of chest showing tumor in right upper thorax. *B*, Lateral view demonstrating posterior position of tumor.

a sharply demarcated mass in the right upper posterior mediastinum (Fig. 5, *A* and *B*).

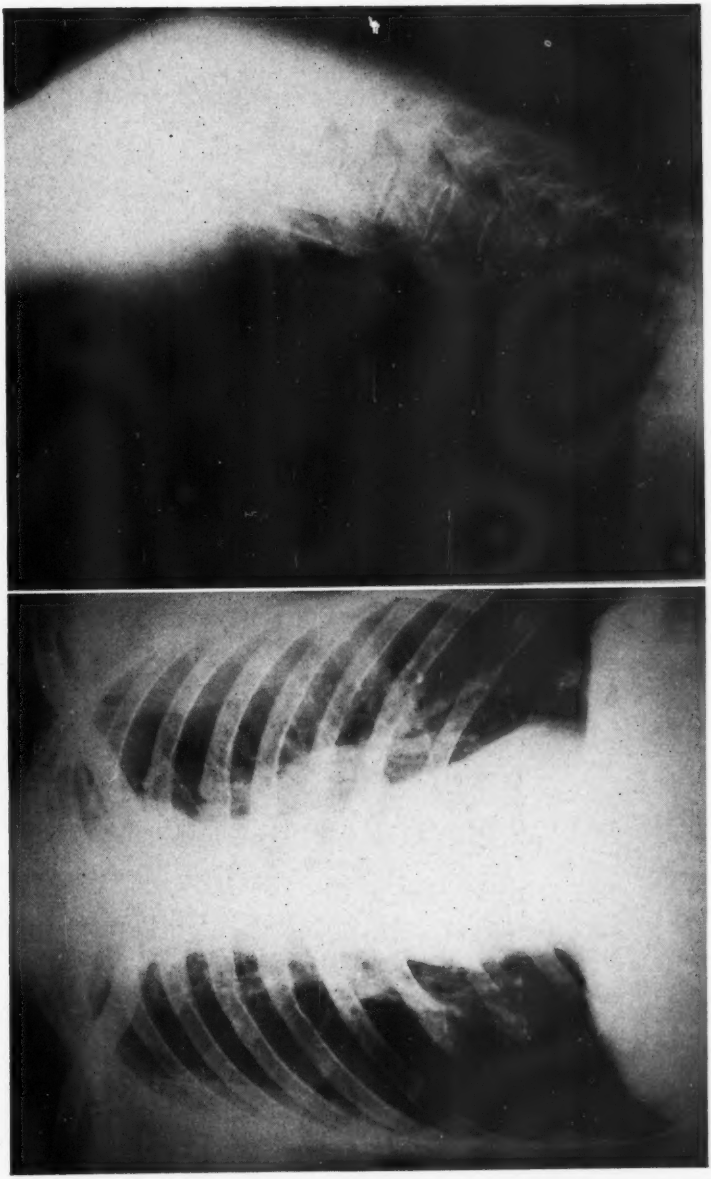
Operation was performed, May 16, 1939, through a posterior approach. The tumor had extended through the chest wall to occupy an area beneath the scapula. When the pleura was opened it was possible to determine the full extent of the mass which extended deeply into the posterior mediastinum and up through the circle of the first rib to become intimately associated with the brachial plexus and the subclavian vessels. Several nerve trunks could be seen running into and over the surface of the mass. All of the intrathoracic portion of the tumor was removed (Fig. 5, *C*), but that part of it which had become adherent to units of the brachial plexus and the subclavian vessels was left in place. Postoperative convalescence was uneventful and the patient was discharged from the hospital, June 4, 1939.



C. *D.*

Fig. 5.—*C*, Fixed gross specimen. *D*, Photomicrograph of section from tumor.

Microscopic study of the tumor revealed undulating groups of cells, considerable collagen, and neuroma formation of the nerve filaments, which were composed almost entirely of neurilemmomas. The changes affecting the nerve fibers were commonly seen involving adjacent muscle

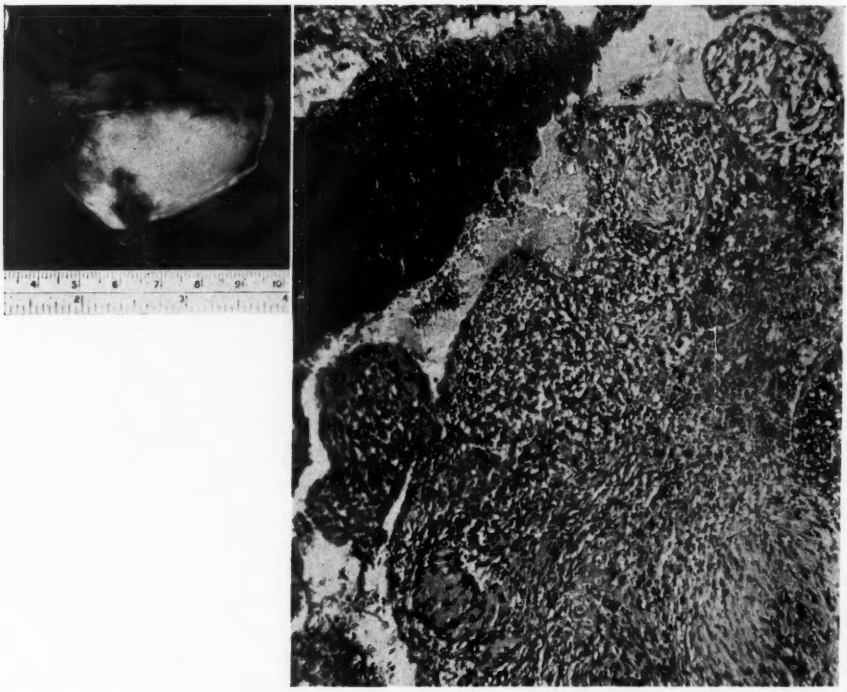


A. *B.*

Fig. 6.—*A*, Roentgenogram of chest revealing tumor in upper mediastinum. *B*, Lateral view shows anterior position of mass.

fibers and blood vessels with such frequency that its significance has been questioned by Dr. N. A. Womack, who made the study of this and other specimens in this report. At some points there was distinct infiltration into adjacent muscles (Fig. 5, *D*) and the question of malignancy is raised as a result of this observation plus the invasive tendency seen at operation.

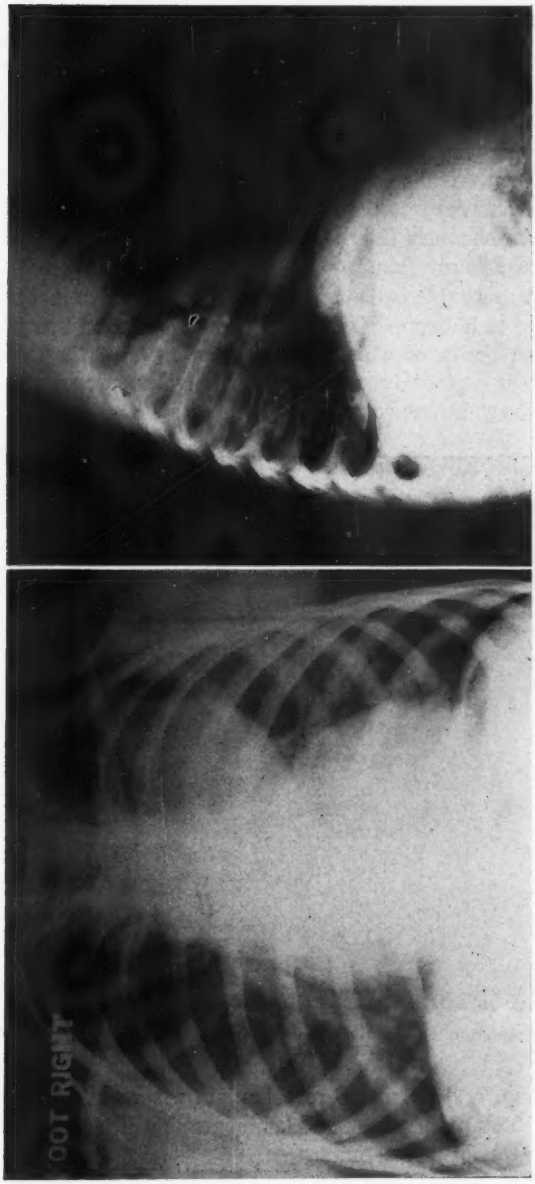
CASE 6.—A 45-year-old white man, was admitted to Barnes Hospital, March 12, 1937. His condition had been studied on several occasions during the previous eight months. There was a history of severe pain



C. *D.*

Fig. 6.—*C*, Photograph of fixed gross specimen. *D*, Photomicrograph of section from specimen.

in the right upper extremity and shoulder for more than two years and in October, 1935, a rhizotomy had been performed elsewhere in an effort to relieve the pain. Subsequent roentgen therapy had yielded only very temporary relief. Physical examination revealed a right Horner's syndrome, paralysis of the right vocal cord, and skin anesthesia over the distribution of the last cervical and first two dorsal segments, the result of the rhizotomy. Roentgenograms revealed a mass in the anterior superior mediastinum (Fig. 6, *A* and *B*).



A. *B.*

Fig. 7.—*A*, Roentgenogram of chest revealing mass in upper left thorax. *B*, Lateral view showing posterior position of tumor.

Operation was performed on March 13, 1937, through an anterior approach. A single firm oval tumor was removed from the upper anterior mediastinum. The postoperative course was uneventful and the patient was discharged from the hospital on the nineteenth postoperative day. There had been no relief from pain.

The tumor mass was completely encapsulated and a benign appearance was suggested. However, microscopic study revealed palisading cells, an edematous almost angiomatous appearance to the sections, papillary excrescences into the lumina of blood vessels, and tissue emboli within vascular channels (Fig. 6, *D*). These observations led to a diagnosis of neurogenic sarcoma.

The follow-up on this patient revealed that the mediastinal tumor did not contribute to his pain. On April 7, 1937, operation was performed by Dr. Ernest Sachs, at which the posterior roots of the third to the seventh thoracic segments were divided. Convalescence was uneventful and relief from pain was complete.

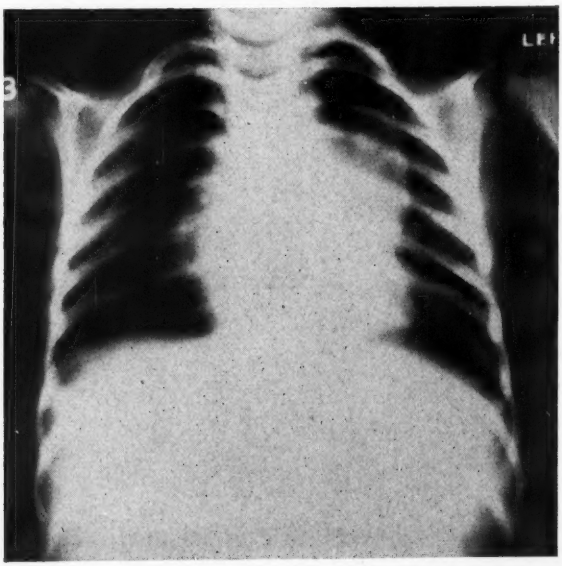


Fig. 7.—*C*, Laminogram on body section radiogram revealing confirmation of posterior position of tumor.

CASE 7.—Fig. 7, *A*, *B*, and *C* reveals plain posteroanterior roentgenogram of the chest, plain lateral and laminograph which all localize tumor in posterior superior mediastinum.

A white female child, 3 years of age, was admitted to St. Louis Children's Hospital, Feb. 19, 1941, because of a tumor of the posterior mediastinum and chest wall, extending to the left side, which had been

discovered accidentally on fluoroscopic examination. The rest of the examination resulted in essentially normal findings. Although a surgical removal of the tumor was advised after preliminary roentgen therapy had failed to reduce its size, the advice was not taken. On November 27, of the same year, however, the child re-entered the hospital and on November 28, an exploratory operation was performed.

A large tumor was found in the costovertebral gutter which infiltrated around the third, fourth, and fifth ribs into the intercostal spaces and back to the vertebrae. It was impossible to remove all the tumor because of both the extensive invasion of the chest wall and excessive hemorrhage which occurred whenever attempts were made to mobilize it. Approximately one-half, however, was removed.

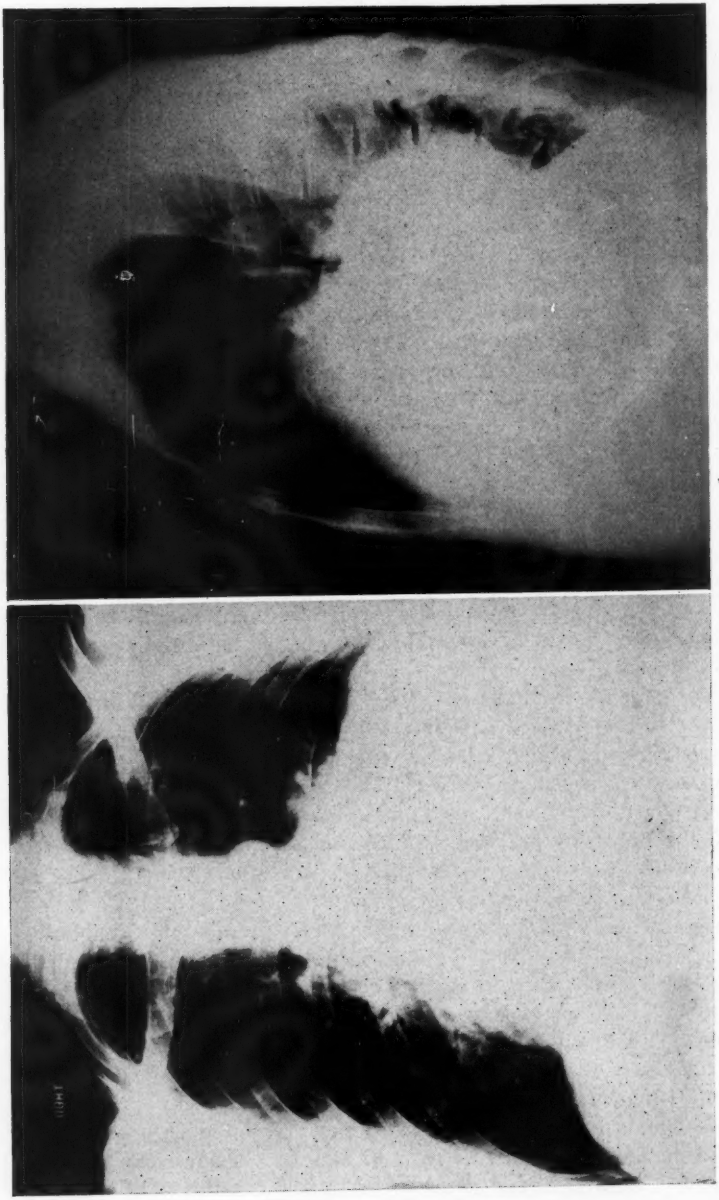
On microscopic examination the tissue was found to contain many rather typical ganglion cells. A diagnosis of ganglioneuroma was therefore made. Although the histologic appearance did not indicate a definitely malignant neoplasm, the gross characteristics with the invasion of the chest wall seemed to demand a diagnosis of malignancy.

Unfortunately, it has not been possible to obtain any information about the subsequent course of this patient after her discharge from the hospital, Dec. 13, 1941. The father was a deserter from the Army, and neither he nor the mother could be traced.

Case 8.—A 49-year-old white man was admitted to Barnes Hospital, June 8, 1937. He complained of cough of eight months' duration, dyspnea upon exertion, loss of eighty pounds, and substernal pain. Physical examination revealed emaciation, dyspnea, and impaired resonance with absent breath sounds over the left lower chest anteriorly. Routine laboratory studies were negative except for a moderate microcytic anemia. Roentgenograms were made and revealed a large anterior mediastinal mass, which projected chiefly into the left chest (Fig. 8, *A* and *B*). Fluoroscopy showed no pulsation of the mass. At bronchoscopy the distorting effect of compression from without upon the left main bronchus and its primary division was seen. Roentgen therapy did not affect the size of the tumor.

Operation was performed, June 28, 1937. It was found impossible to remove the tumor from the mediastinum, the pericardium, and the lower lobe, to all of which it was densely adherent. The tumor was cystic to palpation and caseous material was aspirated from it. A portion of the wall of the tumor was excised for microscopic study. Convalescence was uneventful and the patient was discharged from the hospital, July 17, 1937. No follow-up has been possible.

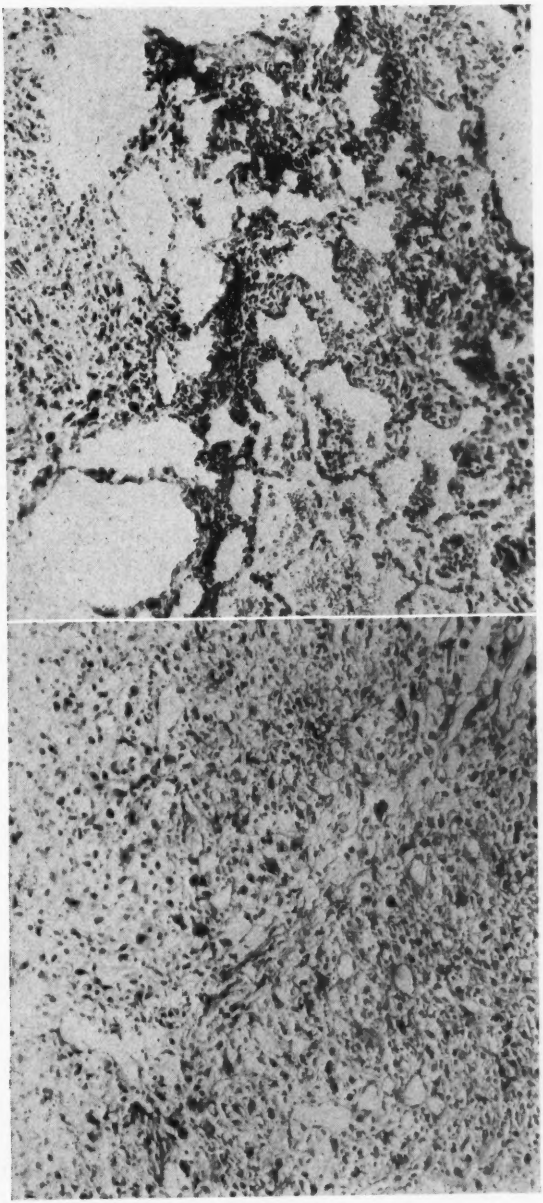
Microscopic examination of the specimen removed at operation revealed an unusual picture (Fig. 8, *C* and *D*). There were numerous extremely large cells and ganglion cells were present. There was invasion of adjacent lung tissue. The cytoplasm of numerous cells was vacuolated, as were the nuclei. Cell polarity was lost, chromatin ma-



B.

A.

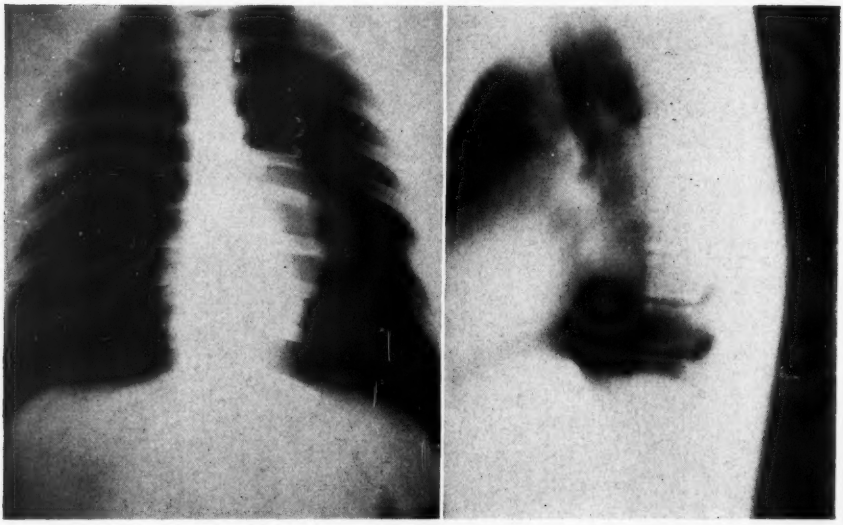
Fig. 8.—*A*, Roentgenogram of chest showing enormous mass in left lower thorax. *B*, Lateral view demonstrating anterior position.



D,

C.

Fig. 8.—*C*, Photomicrograph of section from biopsy. *D*, Photomicrograph from same specimen revealing invasion of lung by tumor cells.



A. *B.*

Fig. 9.—*A*, Laminogram revealing posterior mediastinal tumor. *B*, Confirmation of position by lateral laminogram.

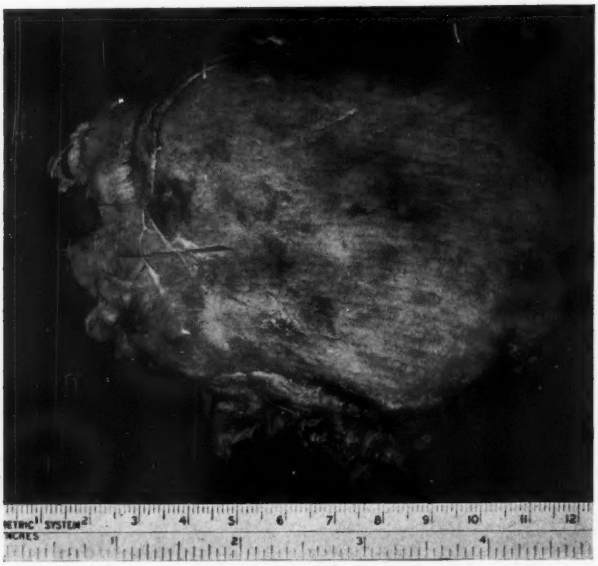


Fig. 9.—*C*, Photograph of fixed gross specimen.

terial was very unevenly dispersed, necrosis was present, and blood spaces were lined by tumor cells rather than endothelium. A diagnosis of ganglioneurosarcoma was made.

This case is unusual for several reasons, but especially because it presents an instance of a large anterior mediastinal tumor which was of nerve tissue origin.

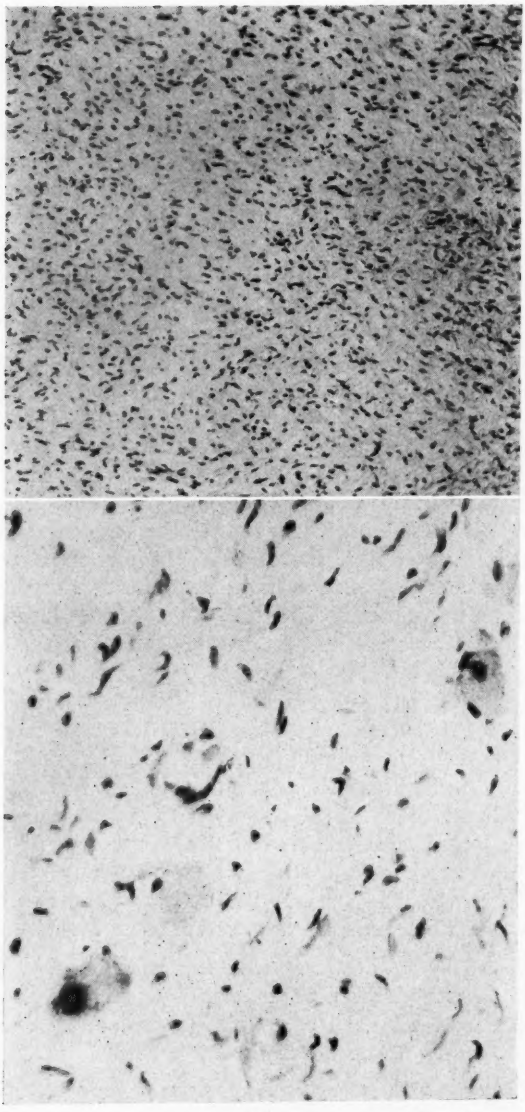
CASE 9.—An 18-year-old white male was admitted to Barnes Hospital, June 29, 1938. He complained of no symptoms but revealed that a scoliosis of the spine had been detected during a routine physical examination six months earlier. Roentgenograms made for study of the spine had shown an intrathoracic mass. Roentgen therapy had been given with no response in the tumor. Physical examination revealed the scoliosis of the spine but was not otherwise remarkable. Routine laboratory examinations yielded negative results. Roentgenographs and laminographic studies (Fig. 9, *A* and *B*) of the chest revealed a sharply outlined mass in the left posterior mediastinum at about the mid-level in the chest. There were evidences of erosion of the seventh and eighth left ribs. Fluoroscopy revealed no expansile pulsation of the mass.

Operation was performed, July 2, 1938, through a posterior approach. The mass was so firmly attached to the bodies of the adjacent vertebrae that it was necessary to leave a thin shell of tumor at these points. However, the remainder of the mass could be dissected from the posterior mediastinum and the chest wall. The postoperative convalescence was uneventful and the patient was discharged from the hospital, July 23, 1938.

The tumor was large (Fig. 9, *C*) and microscopic study revealed palisading of nuclei and also wavy, undulating distribution of nuclei and numerous ganglion cells (Fig. 9, *D* and *E*). Nissl bodies were present and orange G.-aniline blue stains demonstrated that the wavy groups of cells produced collagen. The diagnosis was ganglioneuroma, and although the tumor was unusually cellular and was grossly invasive, it did not seem warranted to classify it as malignant. The diagnosis has been substantiated by the fact that the patient was well, five years after the operation, and in active service with the army.

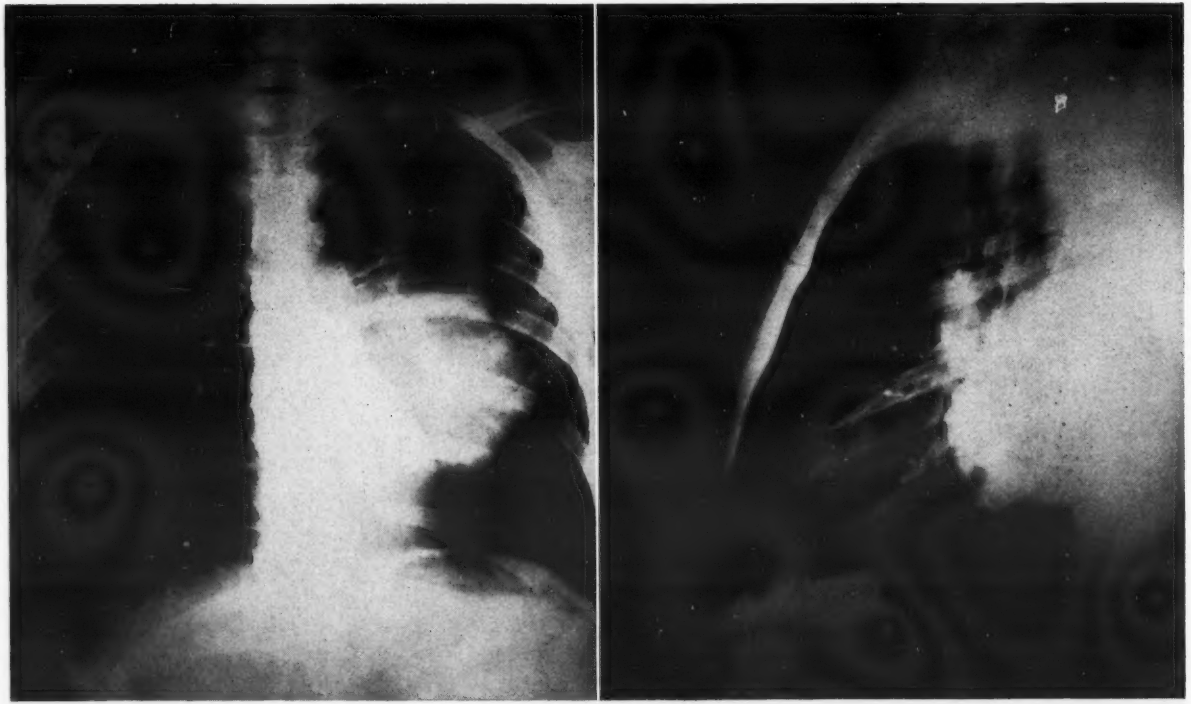
CASE 10.—A 15-year-old white male was admitted to Barnes Hospital, March 3, 1939, complaining of back pain distributed over the mid-thoracic vertebral segments. The pain had been present for six months and he gave a history of trauma to the chest, which occurred two months before the symptoms of pain were noticed. Physical examination revealed an area of impaired resonance and diminished breath sounds to the left of the spine at the mid-chest, and there was a bulging of the chest wall at this point. Routine laboratory studies were negative. Roentgenograms revealed a large, sharply demarcated intrathoracic mass, which was localized to the left posterior mediastinum at the mid-

D.



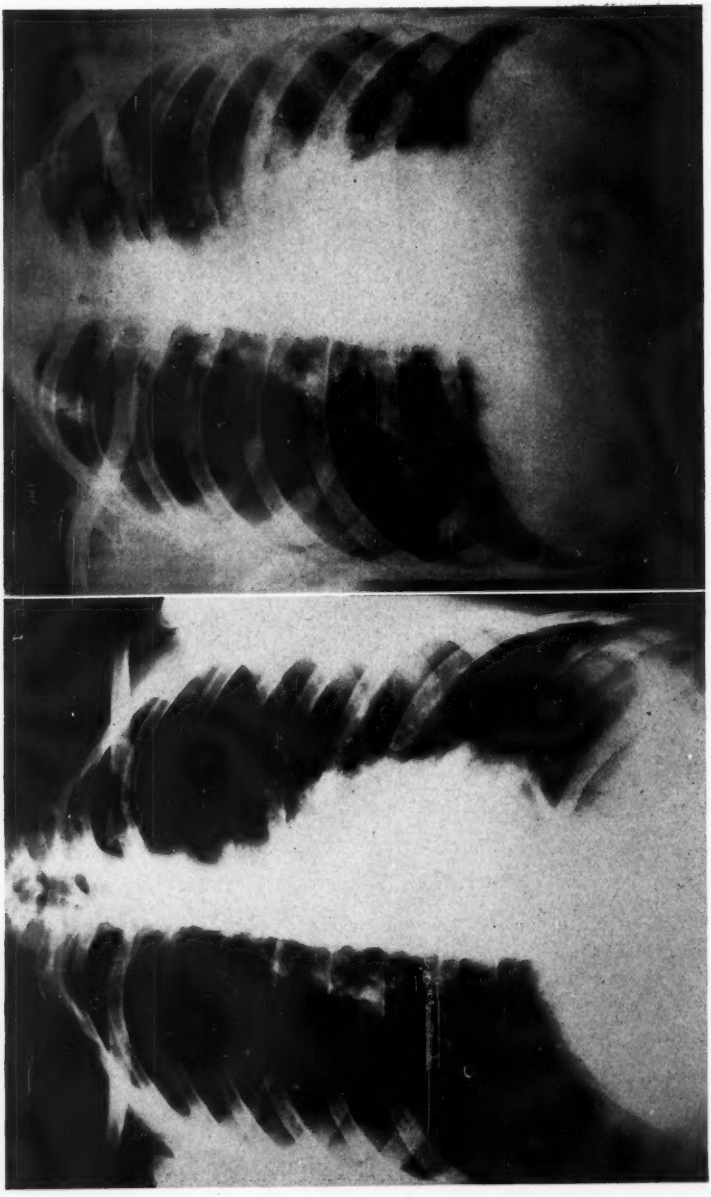
E.

Fig. 9.—*D* and *E*, Photomicrographs from section of specimen.



A. *B.*

Fig. 10.—*A*, Roentgenogram of chest showing tumor in left thorax. *B*, Lateral view showing posterior position.



C. *D.*

Fig. 10.—*C*, Tumor greatly reduced after x-ray therapy. *D*, Recurrence of tumor with pathologic fracture of first right rib.

level of the chest (Fig. 10, *A* and *B*). On fluoroscopy no expansile pulsation was seen. Roentgen therapy resulted in prompt relief of pain and the tumor diminished in size (Fig. 10, *C*). Three months later a recurrence of pain was experienced and roentgenograms of the chest revealed that the tumor had again reached the large size seen upon the original examination. Once more roentgen therapy resulted in relief from pain and a decrease in the size of the mass. In November, 1939, another recurrence of pain took place and a chest film revealed that the tumor was increasing in size once more and that there was a pathologic fracture of the first right rib, probably the result of metastasis (Fig. 10, *D*). Meticulous hematologic studies, including bone marrow puncture, were done at this time, but the results were of no assistance in arriving at a diagnosis. In spite of further radiation therapy, the patient died of the disease at his home and no autopsy was obtained.

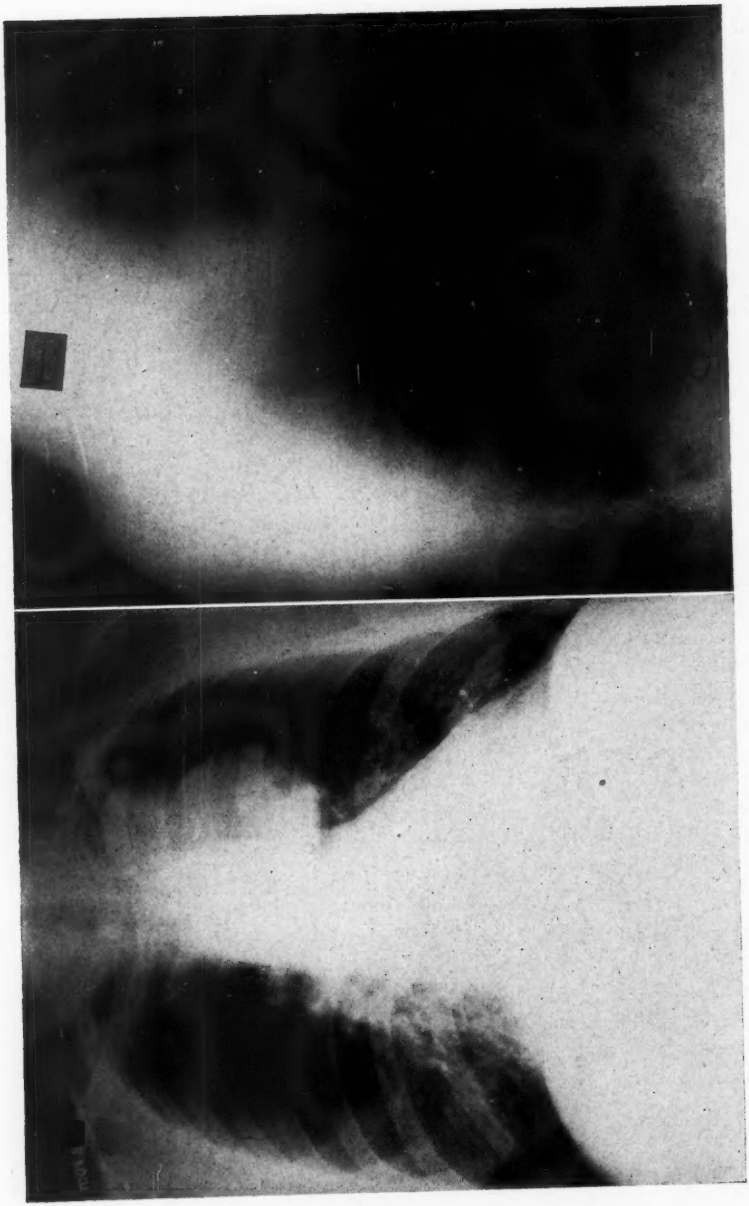
This case is included in the present report because it represents the only case we have seen which closely resembled the picture of a primary nerve tumor of the posterior chest wall near the mediastinum which responded promptly to roentgen therapy. In the absence of microscopic confirmation, the diagnosis cannot be ascertained.

CASE 11.—A 54-year-old physician was admitted to Barnes Hospital Sept. 30, 1929. He gave a history of severe, nonproductive cough of six months' duration, and pain in the left chest of six weeks' duration. Physical examination of the chest yielded no abnormal findings. Routine laboratory examinations, including the basal metabolic rate and an electrocardiogram, were essentially negative. X-ray films revealed a large, clearly outlined, bilobular mass in the left superior posterior mediastinum. The tumor did not pulsate upon fluoroscopy. The patient refused both roentgen therapy and surgical intervention. He has been seen as a patient at Barnes Hospital upon six occasions since 1929 and studies of the chest reveal no change in the tumor.

This tumor remains unverified as to its cytologic characteristics. It does, however, warrant the clinical diagnosis of a primary nerve tumor and this case gives evidence that in patients of a moderately advanced age such tumors may remain stationary for years.

CASE 12.—A 20-year-old white male was admitted to Barnes Hospital, Sept. 30, 1930. An intrathoracic tumor had been detected five years before by roentgenograms. The symptoms were few, limited to moderate nonproductive cough and rare attacks of sharp pain in the left upper chest. A careful check on the progress of the mass had been maintained and it was shown that a steady increase in size had been taking place.

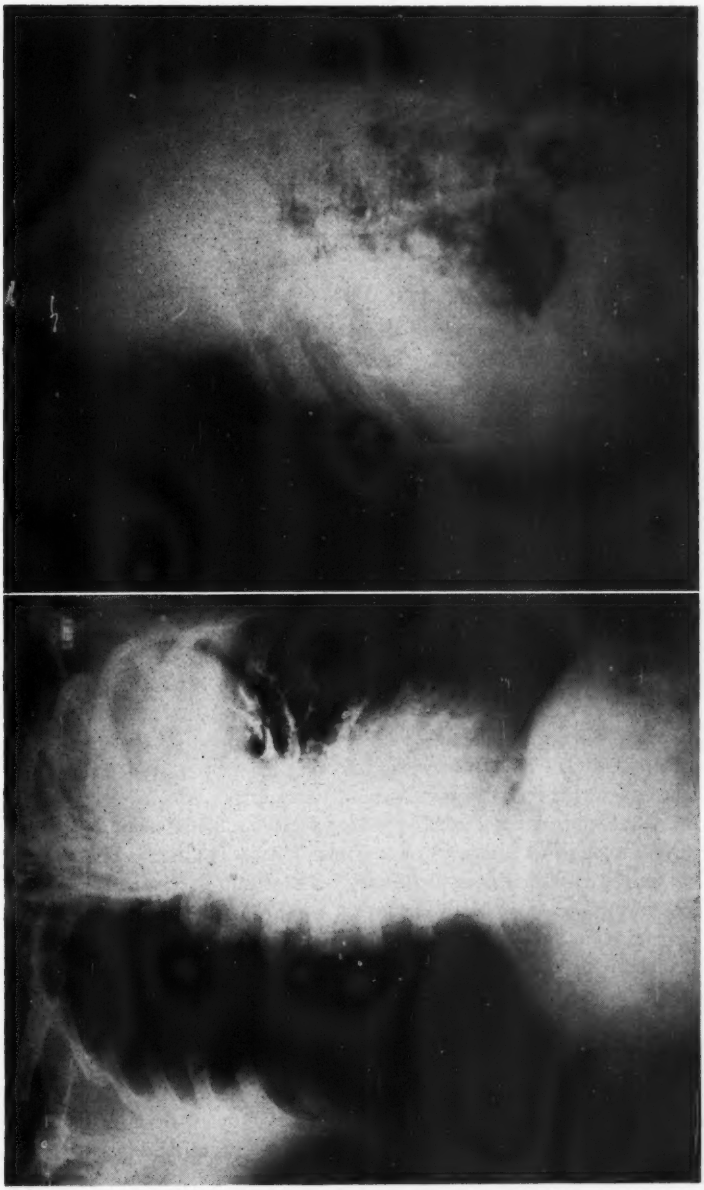
Physical examination revealed impaired resonance and diminished breath sounds over the left upper chest. The heart produced a rough systolic murmur over the base and a coarse thrill was palpable over the



B.

A.

Fig. 11.—*A*, Roentgenogram of chest showing tumor in left thorax. *B*, Lateral view demonstrating posterior position of tumor.



A. *B.*

Fig. 12.—*A*, Roentgenogram of chest revealing large, clearly outlined tumor in left upper thorax. Lipiodol bronchography demonstrates extrapulmonary nature of mass. *B*, Lateral view of same chest.

same area. Routine laboratory studies were not remarkable except for an abnormal electrocardiogram. Roentgenograms of the chest revealed a left mediastinal tumor high in the thoracic cavity. It was clearly outlined, did not pulsate upon fluoroscopy, and bronchograms indicated that the mass was extrapulmonary (Fig. 12, *A* and *B*). There was some erosion of the third and fourth left ribs and of the body of the third dorsal vertebra. A complete neurologic examination yielded negative results and a study of the dynamics of the cerebrospinal fluid gave normal findings. Radiation therapy had been administered with no response. Diagnosis of neurilemmoma was made and surgical removal was recommended. This advice was rejected and the patient left the hospital. Some time later the tumor was removed at another clinic and proved a neurilemmoma. The patient died on the sixth postoperative day.

CASE 13.—A 32-year-old white married woman was admitted to chest service at Barnes Hospital for treatment of a chest tumor first observed eleven years before, when it was the size of a plum. In 1937, a check x-ray film was made which showed no enlargement of the tumor. A film made September, 1943, showed the tumor to be the size of an orange. The patient had always been completely asymptomatic.

Physical examination and laboratory studies were essentially negative. X-ray examination showed a well-demarcated tumor in the upper posterior mediastinum.

This tumor was removed Sept. 21, 1943, through a posterolateral approach. It was found to be attached to the vertebral column and was very easily dissected. The postoperative course was uneventful.

Microscopic examination showed a tumor of the fibrous tissue type, well encapsulated. The tumor was made up of fairly compact spindle cells which grew in bundles and rows of tissue which seemed to be interwoven. In some areas palisading cells were seen. The tumor was more compact in some places than in others and there was a moderate amount of fat tissue reticulum. In some areas of the section degenerative fibrous tissue changes and giant cell formation of the foreign body type were seen. No mitotic figures were seen. In consideration of the microscopic appearance alone the impression is that the tumor was benign; however, with the history of rapid growth necessary to attain its size it would probably be safer to consider the tumor malignant.

Diagnosis: Neurofibroma (malignant).

CASE 14.—A 27-year-old white man was admitted to chest service at Barnes Hospital with a history of pulsating feeling in the left chest and slight dyspnea of three months' duration. He complained also of a pulsation in his left eye as long as he could remember. The patient had Recklinghausen's disease and acromegalia.

Physical examination showed a very large white male who did not appear ill. The patient presented a generalized neurofibromatosis

(Recklinghausen's disease) and the appearance of an acromegalic. His left eye did not protrude evenly with the right and pulsated at intervals. Chest examination was negative.

X-ray examination revealed a tumor mass in the left superior posterior mediastinum. Laboratory studies were negative.

The patient was operated upon March 22, 1943, and the tumor, the size of a large lemon, was removed through a posterolateral approach. The postoperative course was uneventful.

Microscopic study revealed the tumor to be fairly uniform in structure throughout. It was made up of a large sheet of interlacing collagen fibrils in which there were scattered cell nuclei. These cell nuclei were fairly uniform in size but varied considerably in shape. Throughout the tissue there was a moderate number of blood vessels, none of which showed any invasion.

Diagnosis was mediastinal neurofibroma.

CASE 15.—A 23-year-old white married woman was admitted to chest service at Barnes Hospital with a history of dyspnea, easy fatigue, and occasional nonproductive cough of three months' duration.

X-ray picture taken one month prior to admission showed a large right posterior mediastinal tumor.

March 2, 1943, the tumor was removed easily through a posterolateral approach. A large oval-shaped tumor mass was found lying in the vertebral gutter. It measured 10 cm. in diameter and appeared to be attached by a vascular pedicle to the posterior chest wall. The postoperative course was uneventful except for several aspirations of serosanguineous fluid from the right chest.

Microscopic study showed that the cells were fairly regular and mitotic figures could not be found. Throughout the tissue there were many large blood vessels surrounded immediately by tumor cells. The tumor was well encapsulated. Microscopically it appeared benign, but grossly the tremendous size would suggest rapid and possibly malignant growth.

Diagnosis was neurofibroma.

CASE 16.—A 44-year-old white man was admitted to chest service at Barnes Hospital, Jan. 18, 1943, complaining of palpitation of the heart and chest pain of the left side for three months.

Physical examination and laboratory studies were negative. X-ray picture revealed a mass in the left posterior mediastinum.

The patient was operated upon June 21, 1943, through a posterolateral incision. The chest was opened and a tumor mass in the posterior mediastinum was found attached to the vertebral column. The tumor was easily removed and the patient made an uneventful recovery.

Microscopic studies revealed interlacing bundles of nerves and fibrous tissue. Scattered through the fibrous tissue were large vacuolated cells

that on fat stain were seen to contain large quantities of neutral fat. In some areas there was a low-grade chronic inflammatory process.

Diagnosis was neurofibroma.

CASE 17.—A 45-year-old white married woman was admitted to chest service at Barnes Hospital, Nov. 4, 1942, with a history of chronic cough for several years. A tumor mass in the superior anterior mediastinum was found accidentally in a routine examination.

The patient did not appear acutely ill and physical examination was negative. Laboratory studies were negative.

Nov. 6, 1942, the chest was opened through an anterior approach, incision being made along the fold of the breast. A tumor mass, measuring 5 to 8 cm. in diameter, was found attached to the upper end of the pericardium and was freed and removed. The postoperative course was uneventful.

Microscopic study revealed a completely undifferentiated tumor and it was impossible to ascribe an origin to it because several possibilities were to be considered: (1) neurogenic, (2) thymic, (3) reticulum cell sarcoma.

Diagnosis was malignant, mediastinal neoplasm, origin undetermined.

CASE 18.—A 52-year-old white woman was admitted to the chest service at Barnes Hospital with a history of paroxysmal attacks of dyspnea and orthopnea which had been present for four years before admission, but which had become more frequent and severe. An x-ray picture was taken by her local doctor and a tumor mass was found in the left thoracic cavity.

Physical examination revealed the absence of breath sounds in the left upper chest.

X-ray examination revealed a large circumscribed tumor in the left superior posterior mediastinum.

The operation was performed April 7, 1941 and a well-encysted tumor, the size of a small grapefruit, was removed through a posterolateral incision. The tumor was attached to the transverse process at the level of the second dorsal vertebra. The postoperative course was uneventful.

Microscopic studies showed that the tumor was made up chiefly of fibrous tissue which was quite dense throughout and in this dense fibrous tissue could be seen some nerve elements and small blood vessels. No malignant tumor tissue was seen in either of the sections taken.

Diagnosis was neurofibroma.

CASE 19.—A 33-year-old white unmarried man was admitted to the chest service at Barnes Hospital, Dec. 14, 1943. The patient had been completely asymptomatic and routine x-ray examination revealed a tumor mass projecting to the left of the posterior superior mediastinum.

Physical examination and laboratory studies were essentially negative.

The patient was operated upon Dec. 17, 1943. The chest was opened through a posterolateral approach and a tumor mass the size of an orange was found firmly attached to the vertebral column. The tumor was easily removed and the patient had an uneventful postoperative course.

Microscopic studies showed a large, unorganized mass of very edematous collagen and fibrous tissue containing many irregularly dilated engorged veins. No mitotic figures were seen. The wavy fibrous tissue capsule was intact.

Diagnosis was neurofibroma.

CASE 20.—An 11-year-old white male was admitted to St. Louis Children's Hospital, June 27, 1943. The patient was asymptomatic, but in a routine chest examination made in 1942, a tumor mass was found in the left apex.

Physical examination and laboratory studies were essentially negative.

Roentgenologic examination showed a tumor mass in the upper posterior mediastinum.

July 1, 1943, the patient was operated upon and a tumor mass the size of a lemon was found attached to the vertebral gutter and the third intercostal nerve and blood vessel. The tumor was easily removed. The postoperative course was uneventful.

Microscopic studies showed the tumor to be made up of fine connective tissue reticulum and many abnormal nerve bundles running and crisscrossing in various directions. The most striking feature was the presence of numerous large cells which vary in size but which take an even stain. The cytoplasm was homogeneous and dark pink. Several of the large cells showed the typical nerve cell cytoplasmic excrescence. The nuclei were irregular in size and varied from elongated to oval shapes. There were a few scattered lymphocytes and large round cells through the tumor and there was an abundant vascular and lymphatic supply. It was noted that some of the ganglion cells described contained two nuclei.

Diagnosis was ganglioneuroma of mediastinum.

CASE 21.—A 5-year-old white boy was admitted to St. Louis Children's Hospital, Sept. 6, 1943, with a history of pain between the shoulder blades and recurrent attacks of palpitation of seven months' duration.

Physical examination showed a boy who appeared pale and chronically ill with no positive findings except for the chest. There was dullness to percussion over the entire posterior left chest with suppressed breath sounds. The left chest bulged posteriorly.

Laboratory studies were essentially negative except for an anemia. X-ray examination showed a multiloculated tumor arising in the mid-posterior mediastinum.

An exploratory thoracotomy was performed, Sept. 11, 1943, and a multiloculated tumor mass was found attached to the mediastinum, vertebral column, and posterior chest wall. A biopsy was taken from the tumor which was felt to be inoperable and the chest was closed. The postoperative course was uneventful.

Microscopic studies showed the tumor to be composed of a rather dense connective tissue stroma. In one small additional piece of tissue there were seen relatively normal ganglion cells and at the periphery of the ganglion, in contact with the tumor tissue itself, these ganglion cells became increasingly abnormal and proliferating and gradually faded off into the type of tumor cell described previously.

Diagnosis was neurocytoma of the mediastinum.

A tabulated summary of the Barnes Hospital cases is given in Table I.

TABLE I

BARNES HOSPITAL CASES OF INTRATHORACIC NEUROGENIC TUMORS

NUMBER OF CASES	PER CENT
Benign, 10	47.6
Malignant, 9	42.8
Questionable, 2	9.5
Anterior mediastinum, 2	9.5
Posterior mediastinum, 15	71.4
Posterior chest wall, 4	19.0
Total, 21	
Operative mortality, 2	11.1

A statistical tabulation of the cases from the literature is given in Table II.

TABLE II

COLLECTED CASES FROM THE LITERATURE

NUMBER OF CASES	PER CENT
Chest wall tumors, 27	
Malignant, 24	88.8
Benign, 3	11.2
Mediastinal tumors, 74	
Anterior, 3	
Posterior, 71	
Malignant, 15	20.3
Benign, 59	79.7
Number of hourglass tumors, 18	
Total, 105	
Analysis of Deaths	
Total number of deaths, 32	30.4
Operative mortality, 16	15.2
Nonoperative mortality, 16	15.2

The collected cases reported in the literature together with the names of the reporters, the diagnosis, and a brief abstract of each case are given in Table III.

TABLE III

REVIEW OF LITERATURE ON NERVE TUMORS OF MEDIASTINUM AND CHEST WALL

SOURCE	LOCATION OF TUMOR	DIAGNOSIS	DATA
1. Loretz (1870)	Upper posterior mediastinum, 3rd dorsal rib	Ganglioneuroma (hourglass)	Patient was 35-yr.-old female; tumor removed, operative recovery
2. Borst (1902)	Left posterior mediastinum		
3. Von Rindfleisch (1902)	Intrathoracic	Ganglioneuroma	
4. Tschistowitsch (1910)	Right thorax	Ganglioneuroma	12-yr.-old patient
5. Mager (1912)	Posterior mediastinum, 5th dorsal rib	Hourglass tumor	Tumor removed; operative recovery
6. Friedrich (1912)	Right thorax	Ganglioneuroma	73-yr.-old patient
7. Cushing (1920) (Heuer, 1929)	Right posterior inferior mediastinum, 6th dorsal rib	Neurofibroma (hourglass)	Patient was 48-yr.-old female; tumor removed; operative recovery
8. Rosenson (1923)	Right superior posterior mediastinum	Ganglioneuroma (hourglass)	8-yr.-old female; tumor removed; operative recovery
9. Stout (1924)	Upper posterior mediastinum	Ganglioneuroma	2½-yr.-old male; died shortly after removal of tumor
10. Brunner (1924)	Left posterior mediastinum	Ganglioneuroma	19-yr.-old patient; tumor removed; operative recovery
11. Borchardt (1926)	Posterior upper mediastinum	Neurinoma (hourglass)	51-yr.-old male; no operation
12. Borchardt (1926)	Posterior upper mediastinum	Neurinoma (hourglass)	57-yr.-old male; died 5 wk. after removal of tumor
13. Heuer (1929)	Right posterior inferior mediastinum, 4th dorsal rib	Neurinoma (hourglass)	33-yr.-old female; tumor removed; operative recovery
14. Mayer (Heuer, 1929)	Right posterior mediastinum, 6th dorsal rib	Neurinoma (hourglass)	Tumor removed
15. Banse (Heuer, 1929)	Right posterior inferior mediastinum	Neurofibroma (hourglass)	32-yr.-old male; diagnosis proved at autopsy
16. Heuer (1929)	Left superior posterior mediastinum, 2nd dorsal rib	Neurofibroma (hourglass)	48-yr.-old female; diagnosis proved at autopsy
17. Elsberg (Heuer, 1929)	Upper posterior mediastinum, 5th dorsal rib	Ganglioneuroma (hourglass)	3-yr.-old male; died 24 hr. after removal of tumor
18. Elsberg (Heuer, 1929)	Upper posterior mediastinum, 6th dorsal rib	Ganglioneuroma (hourglass)	54-yr.-old male; tumor removed; operative recovery
19. Stout (Heuer, 1929)	Upper posterior mediastinum, 3rd dorsal rib	Ganglioneuroma (hourglass)	3-yr.-old male; died immediately after operation
20. Paget (Heuer, 1929)	Posterior mediastinum, 6th dorsal rib	Hourglass	

TABLE III—CONT'D

SOURCE	LOCATION OF TUMOR	DIAGNOSIS	DATA
21. Riggs and Good (1929)	Neck and mediastinum	Ganglioneuroma	4-yr.-old patient; died 16 mo. after operation
22. Crile and Ball (1929)	Left posterior mediastinum	Ganglioneuroma	8-yr.-old patient; tumor removed, operative recovery
23. Riggs and Good (1929)	Posterior superior mediastinum	Ganglioneuroma	4-yr.-old male; died 2 yr. after removal of tumor
24. Harvey (1930)	Superior right posterior mediastinum	Ganglioneuroma	9-yr.-old male; tumor removed, operative recovery
25. Stewart and Copeland (1931)	Upper posterior chest wall	Neurogenic sarcoma	29-yr.-old male; Recklinghausen's disease, tumor removed, operative recovery
26. Stewart and Copeland (1931)	Posterior chest wall	Neurogenic sarcoma	70-yr.-old female; Recklinghausen's disease, tumor removed, operative recovery
27. Stewart and Copeland (1931)	Left upper posterior chest wall	Neurogenic sarcoma	76-yr.-old female; tumor removed, operative recovery
28. Stewart and Copeland (1931)	Anterior upper chest wall	Neurogenic sarcoma	13-yr.-old male; died 6 mo. after operation; had metastasis to lung
29. Stewart and Copeland (1931)	Anterior chest wall	Neurogenic sarcoma	3-mo.-old female; tumor removed, operative recovery
30. Stewart and Copeland (1931)	Anterior upper chest wall	Neurogenic sarcoma	24-yr.-old male; tumor removed, operative recovery
31. Stewart and Copeland (1931)	Anterior upper chest wall	Neurogenic sarcoma	41-yr.-old male; tumor removed, operative recovery
32. Stewart and Copeland (1931)	Lower posterior chest wall	Neurogenic sarcoma	44-yr.-old patient; tumor removed, operative recovery, x-ray therapy
33. Stewart and Copeland (1931)	Right lateral chest wall	Neurogenic sarcoma	27-yr.-old female; died 2 mo. after removal of tumor
34. Stewart and Copeland (1931)	Upper mid-anterior chest wall	Neurogenic sarcoma	53-yr.-old male; died 1½ yr. after removal of tumor
35. Stewart and Copeland (1931)	Posterior mid-chest wall, 12th dorsal vertebra	Neurogenic sarcoma	21-yr.-old male; tumor removed, operative recovery
36. Stewart and Copeland (1931)	Anterior chest wall	Neurogenic sarcoma	50-yr.-old female; tumor removed, operative recovery
37. Stewart and Copeland (1931)	Interscapular region	Neurogenic sarcoma	57-yr.-old female; died 5 mo. after removal of tumor
38. Stewart and Copeland (1931)	Lower posterior chest wall	Neurogenic sarcoma	67-yr.-old male; died 10 mo. after removal of tumor
39. Stewart and Copeland (1931)	Right posterior chest wall	Neurogenic sarcoma	63-yr.-old male; died 2 mo. after removal of tumor
40. Stewart and Copeland (1931)	Anterior left chest wall	Neurogenic sarcoma	60-yr.-old female; died 7 mo. after removal of the tumor

TABLE III—CONT'D

SOURCE	LOCATION OF TUMOR	DIAGNOSIS	DATA
41. Stewart and Copeland (1931)	Left posterior chest wall	Neurogenic sarcoma	48-yr.-old male; tumor removed, operative recovery
42. Stewart and Copeland (1931)	Chest wall	Neurogenic sarcoma	29-yr.-old male; tumor removed, operative recovery
43. Jackson and Babcock (1931)	Right upper posterior mediastinum	Ganglioneuroma	10-yr.-old female; died on operating table
44. Hosoi (1931)	Upper anterior mediastinum	Edematous fibroma (1927); spindle-cell sarcoma (1928)	28-yr.-old male; Recklinghausen's disease, died 2 mo. after removal of tumor
45. Ranzi, E. (1931)	Superior posterior mediastinum	Fibroganglioneuroma	41-yr.-old female; tumor removed, operative recovery
46. Bigler and Hoyne (1932)	Upper right posterior mediastinum	Ganglioneuroma, malignant	5-yr.-old male; diagnosis verified at autopsy
47. Scott and Palmer (1932)	Left posterior inferior mediastinum	Sympathicoblastoma	22-mo.-old male; diagnsis verified at autopsy
48. Griesbach (1932)	Left upper mediastinum	Ganglioneuroma	11-yr.-old female; tumor removed, operative recovery
49. Eloesser (1933)	Left posterior superior mediastinum	Ganglioneuroma	5-yr.-old male; tumor removed, operative recovery
50. Naffziger and Brown (1933)	Right mid-posterior mediastinum	Hourglass tumor	22-yr-old male; laminectomy with partial removal of tumor; operative recovery
51. Naffziger and Brown (1933)	Right lower posterior mediastinum	Ganglioneuroma (hourglass)	7-yr.-old male; cord portion of tumor removed, patient died 5 mo. later
52. Harrington (1934)	Superior posterior mediastinum	Neurofibroma	27-yr.-old male; no operation
53. Harrington (1934)	Superior posterior mediastinum	Neurofibroma	22-yr.-old male; no operation
54. Harrington (1934)	Superior posterior mediastinum	Neurofibroma	25-yr.-old female; tumor removed, died 5 days after operation
55. Harrington (1934)	Inferior posterior left mediastinum	Neurofibroma	45-yr.-old male; tumor removed, operative recovery
56. Harrington (1934)	Inferior posterior mediastinum	Neurofibroma	22-yr.-old male; tumor removed, operative recovery
57. Harrington (1934)	Inferior posterior mediastinum	Neurofibroma	30-yr.-old male; tumor removed, operative recovery
58. Harrington (1934)	Superior posterior mediastinum	Neurofibroma	41-yr.-old female; tumor removed, operative recovery
59. Harrington (1934)	Inferior posterior mediastinum	Neurofibroma	39-yr.-old male; tumor removed, operative recovery
60. Harrington (1934)	Right lateral chest wall, 8th rib	Neurofibrosarcoma	35-yr.-old female; tumor removed along with 8th, 9th, and 10th ribs, operative recovery

TABLE III—CONT'D

SOURCE	LOCATION OF TUMOR	DIAGNOSIS	DATA
61. Harrington (1934)	Left superior posterior mediastinum	Neurofibroma	46-yr.-old female; no operation
62. Harrington (1934)	Left posterior inferior mediastinum	Neurofibrosarcoma	38-yr.-old female; tumor removed, operative recovery
63. Harrington and Craig (1934)	Left upper posterior mediastinum	Fibroblastoma (hourglass)	25-yr.-old female; tumor removed, operative recovery
64. Harrington and Craig (1934)	Left upper posterior mediastinum	Fibroblastoma (hourglass)	34-yr.-old female; tumor removed, operative recovery
65. Bohrer and Lincoln (1934)	Right upper posterior mediastinum	Ganglioneuroma	5-yr.-old female; died of hemorrhage after removal of tumor
66. Andrus (1937)	Posterior superior mediastinum	Ganglioneuroma	5-yr.-old female; tumor removed, died 5 hr. after operation
67. Andrus (1937)	Right superior posterior mediastinum	Neurofibroma	55-yr.-old male; tumor removed, died 1 day after operation
68. Harrington et al. (1935)	Inferior posterior mediastinum derived from intercostal nerve	Fibrosarcoma	50-yr.-old male; tumor removed, operative recovery
69. DiStefano (1935)	Inferior posterior mediastinum	Ganglioneuroma	12-yr.-old female; no operation, diagnosis verified at autopsy
70. Cutler and Gross (1936)	Posterior chest wall, 5th intercostal nerve	Neurofibrosarcoma	30-yr.-old female; tumor removed, died 5 yr. later
71. Cutler and Gross (1936)	Posterior chest wall, 8th intercostal nerve	Neurofibroma	27-yr.-old female; tumor removed, operative recovery
72. Cutler and Gross (1936)	Anterior superior mediastinum, arising from phrenic nerve	Neurofibroma	35-yr.-old male; tumor removed, operative recovery
73. Cutler and Gross (1936)	Right arm with metastasis to both lungs 4 mo. later	Neurofibrosarcoma	56-yr.-old male; tumor removed, died 4 mo. later
74. Churchill (1936)	Posterior superior mediastinum appeared to be anterior because of long pedicle	Neurofibroma	55-yr.-old male; tumor removed, operative recovery
75. Churchill (1936)	Right posterior mediastinum	Neurofibroma	18-yr.-old male; tumor removed, died 1 wk. after removal
76. Sophian (1935)	Upper posterior mediastinum	Ganglioneuroma	7-yr.-old female; tumor removed, operative recovery
77. Ceballos (1936)	Left upper posterior mediastinum	Neurofibroma	39-yr.-old female; tumor removed, operative recovery
78. Andrus and Heuer (1936)	Left mid-posterior mediastinum	Neuroblastoma	9-yr.-old male; died 6th postoperative day
79. Andrus and Heuer (1936)	Right superior posterior mediastinum	Myxoneurofibroma	39-yr.-old female; tumor removed, operative recovery
80. Epstein (1937)	Superior posterior mediastinum	Neurofibroma	4-yr.-old female; tumor removed, operative recovery

TABLE III—CONT'D

SOURCE	LOCATION OF TUMOR	DIAGNOSIS	DATA
81. Cabot Case (23182) (1937)	Anterior left mediastinum	Fibrosarcoma	31-yr.-old male; tumor removed, operative recovery
82. Overholt and Souder (1937)	Left lower posterior mediastinum	Ganglioneuroma	23-yr.-old female; died after operation
83. Cernoevic (1937)	Upper left mediastinum	Angiofibroneuroma	28-yr.-old male; tumor removed, operative recovery
84. Hart and Ellison (1937)	Posterior inferior mediastinum	Ganglioneuroblastoma	6-yr.-old male; tumor removed, operative recovery
85. McNally (1937)	Upper posterior mediastinum	Neurofibroma	20-yr.-old colored female; primigravida, 2 wk. after cesarean, tumor removed, operative recovery
86. Charache (1938)	Lateral chest wall	Neurogenic sarcoma	22-yr.-old female; tumor removed, operative recovery
87. Charache (1938)	Lateral chest wall	Neurogenic sarcoma	35-yr.-old female; tumor removed twice, patient died 3 yr. later
88. Charache (1938)	Posterior chest wall	Fibrosarcoma	15-yr.-old female; tumor removed several times, died 4 yr. later, metastasis to lungs
89. Charache (1938)	Posterior chest wall	Neurofibroma	57-yr.-old female; tumor removed, operative recovery
90. Filippi (1938)	Left posterior superior mediastinum	Neurofibroma	37-yr.-old female; tumor removed, operative recovery
91. Maksin et al. (1939)	Left chest, rooted in apex and neck and posterior mediastinum	Neurofibrosarcoma	12-yr.-old female; adrenals, tumors, and neurofibromatosis, diagnosis verified at autopsy
92. Allison and Carmichel (1939)	Left upper posterior mediastinum	Ganglioneuroma	10-yr.-old male; tumor removed, operative recovery
93. Clark (1938)	Right upper posterior mediastinum	Ganglioneuroma	17-yr.-old female; died on operating table
94. Chandler and Norcross (1940)	Right posterior inferior mediastinum	Sympathicoblastoma	18-mo.-old female; died 4 mo. after biopsy taken
95. Chandler and Norcross (1940)	Right posterior inferior mediastinum	Sympathicoblastoma	9-yr.-old male; died 6 mo. after removal of tumor
96. Chandler and Norcross (1940)	Left posterior mediastinum	Sympathicoblastoma	6-yr.-old male; died 4 mo. after biopsy taken
97. Lavender and Prentice (1940)	Right upper posterior mediastinum	Neurofibroma	56-yr.-old female; tumor removed, operative recovery
98. Arce (1941)	Right posterior upper mediastinum	Neurofibroma	29-yr.-old female; tumor removed, operative recovery
99. James and Curtis (1941)	Inferior posterior mediastinum	Ganglioneuroma	35-yr.-old female; tumor removed, operative recovery

TABLE III—CONT'D

SOURCE	LOCATION OF TUMOR	DIAGNOSIS	DATA
100. Odessky (1941)	Left lateral upper chest wall	Neurinoma	37-yr.-old female; tumor removed, operative recovery
101. Blake and Bradford (1943)	Right lateral chest wall	Fibrosarcoma	20-yr.-old male; died 15 mo. after biopsy taken
102. Schaffner et al. (1943)	Right posterior upper mediastinum	Neurofibroma	35-yr.-old male; tumor removed, operative recovery
103. Schaffner et al. (1943)	Right upper posterior mediastinum	Ganglioneuroma	19-yr.-old male; tumor removed, operative recovery
104. Schaffner et al. (1943)	Right mid-posterior mediastinum	Ganglioneuroma	35-yr.-old female; tumor removed, operative recovery
105. Wahl and Robinson (1943)	Superior posterior mediastinum	Neuroblastoma	4-yr.-old male; no operation, diagnosis verified at autopsy

SUMMARY

A series of 18 cases of proved intrathoracic nerve tumors from the Barnes Hospital is presented. In addition, 3 other cases of probable but not proved neurogenic tumors are reported. A collected series of 105 cases from the literature is reviewed.

From this study it is clear that in a high percentage of cases the tumors are malignant. In our personal series no less than 41 per cent were found malignant, and in the collected cases from the literature 37 per cent were malignant. It is obvious, therefore, that there is no justification for the all too common opinion of the medical profession that suspected nerve tumors of the thorax do not require operation unless, or until, pressure effects have been noted. On the contrary, it would seem wiser to take a position that the presumptive diagnosis of such a tumor constitutes a sufficient indication for operation.

The location of intrathoracic nerve tumors is overwhelmingly in the posterior part of the chest, either in the posterior mediastinum or close to it. This tumor is the most common one in that region.

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ROENTGENOGRAPHIC DEMONSTRATION BY DIODRAST OF THE PLEURAL WALLS IN OPEN EMPYEMA

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IN THE treatment of open empyema, it is desirable to know the location, size, and ramifications of the empyema space. This information is particularly helpful when operative intervention is indicated for obliteration of the space.

The most valuable method of studying these empyema cavities is by means of roentgenography, particularly with the aid of a contrast medium.[1, 2] Several kinds of radiopaque materials have been used in the past, and as drawbacks and unsatisfactory results were noted, other preparations were introduced. The use of some of these has largely been abandoned, bismuth because of its retention by the tissue and the danger of poisoning, and potassium iodide and thorium nitrate because of irritation and discomfort to the patient.[1] Lipiodol was later introduced and since the original studies by Sicard and Forestier[3] has been widely used in a variety of situations as an aid in roentgenographic visualization.

In pleural cavities, the oily solutions (lipiodol, brominol, iodochlorol) have been used with incomplete success. In order to visualize satisfactorily empyema spaces of any size, a fairly large quantity of the relatively expensive oily material must be used to fill the space. Moreover, in posturing the patient for radiographic study, it is necessary to plug the chest opening to prevent the escape of the solution. The roentgenogram then depicts a dense, homogeneous shadow which may not always indicate the true extent of the empyema cavity (Fig. 1). In other instances somewhat smaller amounts of oil have been used and the patient shifted about in an effort to coat the walls of the pleural space and the excess drained off. This, however, has given an incomplete outline and a somewhat blotchy appearance to the roentgenogram since the oily solution adheres poorly and tends to form in globules (Fig. 2). At times some of the oil is retained and since it is slowly absorbed, its presence may be confusing in later roentgenograms.

Farinas[4] satisfactorily outlined the bronchial tree by utilizing a watery contrast solution in spray form. It occurred to us that this procedure, using a watery solution, might prove serviceable for outlining the walls of an empyema cavity. By the technique here described, roentgen-

From the New York State Hospital for Incipient Pulmonary Tuberculosis.
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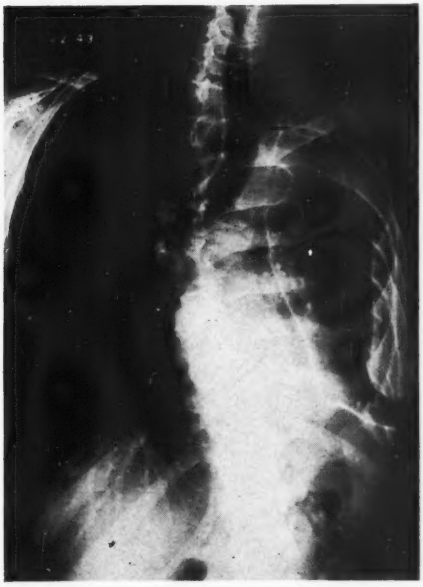

Fig. 1.

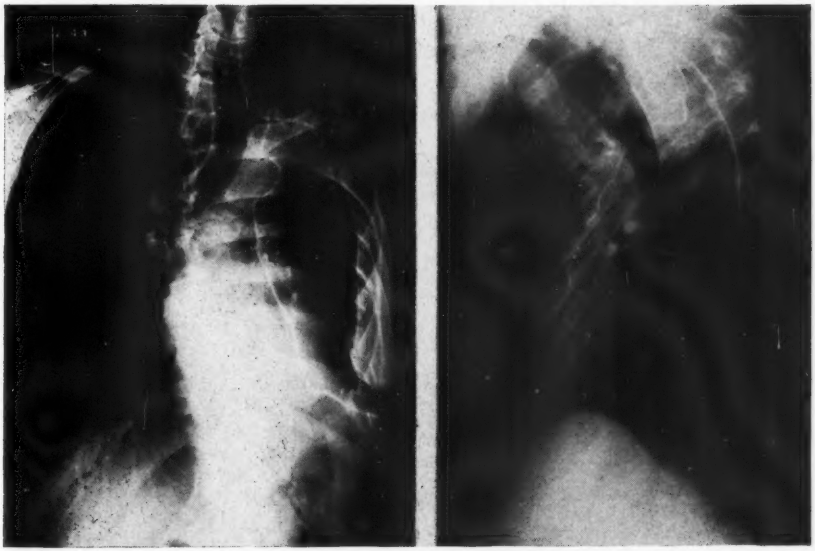

Fig. 2.

ograms have been obtained which clearly define the extent of these spaces, thereby eliminating the disadvantages noted.

Materials and Procedure.—Thus far, two types of contrast media have been employed, diodrast solution 35 per cent and skiodan in acacia solution.* It is necessary, however, to keep the skiodan in acacia solution warm to prevent plugging of the atomizer from the drying effect of the air blast. As a preparatory measure, the empyema space should be thoroughly irrigated with saline or azochloramide solution to remove any loose coagulum that might be present. The coagulum takes up the contrast medium and obscures the roentgenographic outline of the wall. A nebulizer containing 10 c.c. of the watery contrast solution is connected to a small air pump of the Jordan or Sorenson type. The patient lies with the affected side uppermost and the tip of the nebulizer is introduced through the thoracotomy wound. The opening must be sufficiently large to allow for the free egress of air as the material is being sprayed on all the walls to avoid the discomfort of any pressure within the chest cavity. The patient is then tilted toward the side of the open wound and the excess fluid is drained off. Roentgenograms in the posteroanterior and lateral positions should be taken immediately as the contrast medium is rapidly absorbed. If the outline is incomplete, or unsatisfactory, the surfaces may again be sprayed and reexamined.

It was possible to verify the roentgenographic outline at subsequent unroofing operations. The method was also helpful in clearly outlining a residual pocket. The procedure would not be useful in the demonstration of noncommunicating or incompletely drained loculations inaccessible to the spray.

At present, the procedure has been used only in open pleural cavities to avoid the discomfort of increased pressure needed in forming the spray. However, additional studies are under way to develop, if possible, a method whereby the diodrast may be employed for the clearer definition of pleural adhesions in closed pneumothorax for pulmonary tuberculosis.

The advantages of this technique are noted as follows:

1. A sharply defined linear configuration is obtained giving a fairly accurate idea of the size and distribution of the empyema space rather than a homogeneous dense shadow.

2. The contrast medium is rapidly absorbed and therefore no residuum is present to confuse later roentgenographic examinations.

3. The thickness and surface appearance of the pleura may be noted as the borders of the empyema cavity are indicated by a linear shadow.

4. The solution used is innocuous and the small quantity required makes it comparatively inexpensive.

*Supplied by Winthrop Chemical Company, Inc.

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2. Graham, E. A., Singer, J. J., and Ballon, H. C.: Surgical Diseases of the Chest, Philadelphia, 1935, Lea & Febiger, p. 157.
3. Sicard, J. A., and Forestier, J.: The Use of Lipiodol in Diagnosis and Treatment: A Clinical and Radiological Survey, New York and London, 1932, Oxford University Press.
4. Farinas, P. L.: Mucosography of the Respiratory Tract, Radiology **39**: 1, 1942.

THE AMERICAN ASSOCIATION FOR THORACIC SURGERY

TWENTY-FIFTH ANNUAL MEETING, MAY 5 AND 6, 1944, AT THE DRAKE, CHICAGO, ILL.

Program

Friday Morning, May 5, 1944

9:00 A.M. BUSINESS MEETING

9:30 A.M. SCIENTIFIC SESSION

1. **The Management of Stricture of the Esophagus**
   Ralph Adams and (by invitation) Walter Hoover
2. **The Management of Benign Tumors of the Esophagus**
   Stuart Harrington
3. **Causes of Mortality Following Radical Resection for Carcinoma of the Esophagus**
   John Garlock
4. **Current Observations on Thoracic Surgery in the Present War**
   B. Noland Carter and Michael DeBakey
5. **War Wounds of the Chest Observed at the Thoracic Surgery Center, Walter Reed General Hospital**
   Brian Blades and (by invitation) David J. Dugan

Friday Afternoon, May 5, 1944

2:00 P.M. SCIENTIFIC SESSION

6. **Difficulties in the Differential Diagnosis of Bronchogenic Carcinoma**
   Robert G. Bloch, W. E. Adams, and (by invitation) Thomas F. Thornton and J. E. Bryant
7. **Bronchial Adenoma**
   C. L. Jackson and (by invitation) Frank Konzelman and Charles Norris
8. **Bronchoscopic Cinematography of Bronchial Tumors**
   Paul Holinger and (by invitation) Ralph G. Rigby
9. **The Problem of So-called Adenoma of the Bronchus**
   Evarts A. Graham and (by invitation) Nathan A. Womack
10. **Resection of the Thymus for Myasthenia Gravis**
    Alfred Blalock

6:30 P.M. Cocktail Party

7:30 P.M. Banquet, The Drake

Saturday Morning, May 6, 1944

9:00 A.M. SCIENTIFIC SESSION

11. **Indications for Pericardiotomy With Special Reference to Exposure of the Infected Patent Ductus Arteriosus**
    Harold Neuhof
12. **Arteriovenous Fistula of the Lung**
    John C. Jones

13. **Hyatid Disease of the Lung**
    Louis Davidson
14. **Studies of the Pathogenesis, Dynamics, and Closure of Tension Cavities**
    H. McLeod Riggins and (by invitation) Robert P. Gearhart
15. **The Determination and Treatment of Pressure Cavities in Pulmonary Tuberculosis, Moving Picture Demonstration**
    Arthur M. Vineberg and (by invitation) Walter E. Kunstler
16. **An Evaluation of Monaldi Suction Drainage in the Treatment of Tuberculous Pulmonary Cavities**
    Jerome Head

Saturday Afternoon, May 6, 1944

2:00 P.M. EXECUTIVE SESSION

2:30 P.M. SCIENTIFIC SESSION

Pulmonary Resection in the Treatment of Tuberculosis—Introductory Remarks
Frank S. Dolley

17. **Total and Partial Pneumonectomy in the Treatment of Pulmonary Tuberculosis**
    Robert M. Janes
18. **Lobectomy in Pulmonary Tuberculosis**
    Herbert C. Maier and (by invitation) Robert Klopstock
19. **Primary Upper Lobectomy Versus Modern Selective Thoracoplasty**
    J. Maxwell Chamberlain
20. **The Use of Whole Blood Transfusions in Resection of the Lung**
    W. E. Adams and (by invitation) T. F. Thornton, Jr., J. Edmund Bryant, and Leffie M. Carleton
21. **Studies in Oleothorax**
    Paul D. Crimm and (by invitation) Veronica F. Martos

Correspondence

To the Editor:

In the December issue of the Journal of Thoracic Surgery Dr. Julian Johnson emphasizes a fact which most of us are well aware of, namely, that following total pneumonectomy it is well to have the patient lie on the side operated upon for the greater part of the time during his convalescence. This fact cannot be too strongly nor too often emphasized. It is very easy to have the patient *prefer to* lie on the operated side by using a most simple procedure, which we first used many years ago following the second and third stage of thoracoplasties—long before we had any successful total pneumonectomies—that is as follows: As soon as the operation is completed place the patient on his operated side while he is still asleep and keep him there until he wakens and for the first four or five hours after he is awake. If this is done it will be found that the patient by preference assumes this position as the most comfortable one. It is only the very exceptional patient on whom it may be necessary, during the first few postoperative days, to enforce this position.

Ralph B. Bettman, M.D.